THE CHEMISTRY OF CHALCONES AND RELATED COMPOUNDS

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DEDICATED TO THE

MEMORY

OF

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FOREWORD

The chemical literature has grown enormously since the last war. It becomes increasingly difficult to read meaningfully what is published. Fortunately, the literature of Organic Chemistry is presented in internationally readable structural formulae. It is, as a consequence, far easier to find what is novel in the literature of Organic Chemistry than it is in the literature of (say) Biochemistry. Nevertheless, the physical burden of reading all the world's literature in Organic Chemistry as it becomes available is becoming a herculean task. Even if one works sixteen hours a day one would still not manage to read carefully all that is published.

One solution to this problem, that is increasingly adopted is not to bother to read the literature at all. One then relies on review articles, on attendance at meetings, on osmosis from one's friends and neighbours and on specialised monographs, for keeping oneself up to date.

This book by Dr. D.N. Dhar is a good example of a valuable specialised monograph. It deals in detail with the chemistry of chalcones and includes sections on physical properties and on biological activities.

However, a book like this is not only a pleasure to read as an authoritative treatise on an important subject, it also serves as a valuable reference book.

Dr. Dhar deserves the heartfelt thanks of the International Community of Organic Chemists for making available this splendid and up to date monograph. It will serve a very useful purpose.

Gif-sur-Yvette, France August 19, 1980

Sir Derek Barton

PREFACE

The chemistry of chalcone has been recognized as a significant field of study. The phenomenal growth of publications in this area is undoubtedly a reflection of the interest it is receiving throughout the world. Unfortunately no book has appeared to date dealing exclusively with the broad aspects of chalcone chemistry. It was, therefore, felt that there exists a need for such a book which not only gives a background information about chalcones, but also provides a bird's eye view of the entire field. The work has been extended to include some derivatives of chalcones. The literature appearing in major journals and chemical abstracts has been covered through 1979.

The general arrangement of the book is as follows:

It is divided into four parts, comprising 19 chapters.

Part I (Chapters 1-3) deals with an introduction to the subject and highlights the various methods of synthesis of substituted chalcones and includes some of the naturally occurring chalcones, viz., carthamin, sophoradin etc.

Part II comprises six chapters (Chapters 4-9) which are essentially concerned with the various reactions of chalcones, for example, their reactions with oxidizing and reducing agents, ketones, esters, amides, cyanides, amines, organometallics, halogens etc. This includes cyclisation (chemical as well as biochemical), photochemical and polarographic

reactions. The physical properties of chalcones, including spectroscopic, X-ray crystallographic and dipole moment measurement studies form the subject matter of part III (Chapters 10-15) of the book. The colour reaction detection and estimation of chalcones are dealt with in Chapter 12. while the chromatographic methods of separation of chalcones from other flavonoids are described in Chapter 15. A list of naturally occurring chalcones, with some of their derivatives, is given in Chapter 16. Some of the chalcones are reported to inhibit the growth of several pathogenic microorganisms, fungi and are also claimed to exhibit some interesting therapeutic properties, viz., hypotensive and antipeptic ulcer activities (Chapter 17). Some of the chalcones and their derivatives find applications or are being considered for potential use, and these are covered in Chapter 19 (Part IV) of this book. Examples of these applications are the artificial sweeteners, stabilizers against heat, light and ageing of several materials, analytical reagents, scintillators polymerisation catalysts, preparation of photoconducting compositions etc. Chapter 18 is devoted in particular, to the reactions of two important derivatives of chalcones, viz., epoxides and <, β -dibromides. These compounds serve as useful starting materials for the preparations of a large variety of related compounds. Comprehensive subject and author indexes arranged alphabatically, are

appended towards the end of the book.

It is my privilege to thank Prof. Sir Derek Barton, D.Sc., F.R.S., Nobel Laureate, for kindly contributing the Foreword to this book.

The writing of the concluding chapters of this book was done during an enjoyable visit to Shemyakin Institute of Bio-organic Chemistry U.S.S.R Academy of Sciences, Moscow, and I take this opportunity to thank Academicians Yu.A. Ovchinnikov and I.V. Torgov for their generous hospitality.

It is indeed a pleasure to acknowledge the assistance of my students, viz., Drs. A.K. Banerjee, S.C. Suri, A.K. Singh, P. Dwivedi, M/S. H.C. Misra, R. Raghunathan and K.S.Kashavamurth who by their enthusiastic cooperation and generous donation of time and effort helped to make the book a reality. My thanks are due to Dr. S.S. Misra who undertook the arduous task of assisting me in literature survey. It is also a pleasure to record my appreciation to M/S. A.C. Saha, Anil Kumar and Bishember Nath for their continued cooperation.

I wish to thank the Educational Development Centre as well as the Curriculum Development Centre (Quality Improvement Programme) I.I.T. Kanpur for providing the financial assistance for preparation of the manuscript.

Finally, I wish to express my gratitude to my wife,
Rupa, and my children, Preeti and Pankaj, for their understanding
and patience during the period the work was in progress.

Kanpur, INDIA

Durga Nath Dhar

May 15, 1980

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ABBREVIATIONS

Ac	Acetyl	DNPH	Dinitrophenylhydrazine
Alc	Alcoholic	EDTA	Ethylenediaminetetraacetic acid
Aq	Aqueous	m4	
Ar	Aryl	It .	Ethyl
В	Base	Liq	Liquid
Bz	Benzoyl	LAH	Lithium Aluminium hydride
	•	LC P	Lithium Chloropalladite
MBS	N-Bromosuccinimide	Me	Methyl
Bu	Butyl	NDA	N.N-Dimethylaniline
Conc	Concentrated	Nu	
DME	Dimethoxyethane		Nucleophile
DMAD	Dimethylacetylene-	Ph,Ø	Phenyl
ントのPiga Temperature	dicarboxylate	PPA	Polyphosphoric acid
DMC	N,N-Dimethylchalcone	Py	Pyridine
DE	Dimethylformamide	Satd	Saturated
DMSO	Dimethylsulphoxide	TN	Thallic nitrate
MSOM	Dimethylsulphoxonium methylide	Тв	Tosylate

PART - I

CHAPTER - 1

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INTRODUCTION

Benzylideneacetophenones constitute a class of naturally occurring pigments which are oftentimes referred to as 'Chalcones'. The term was first coined by Kostanecki¹, who did pioneering work in the synthesis of natural coloring compounds. An interesting feature of chalcones (polyhydroxylated) is that these serve as starting materials for the synthesis of another class of naturally occurring and widely distributed pigments called flavones.

CLAISEN-SCHMIDT REACTION

The synthesis of chalcone, the parent member of the series, has been accomplished in a variety of ways but perhaps the simplest method is the one involving the Claisen-Schmidt reaction. It consists in the reaction of acetophenone with benzaldehyde, in the presence of aqueous alkali or sodium ethylate, resulting in the formation of α . β -unsaturated ketone²:

$$c_6H_5cocH_3 + c_6H_5cho$$
 Base $c_6H_5cocH:cHc_6H_5 + H_2o$

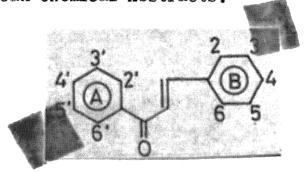
The substituted benzylideneacetophenones have likewise been obtained by condensing the appropriately substituted acetophenone with substituted benzaldehyde in the presence of alkali.

Mechanism of chalcone formation

Kinetic studies have been reported for the base catalysed formation of chalcone $^{3-5}$ and its derivative 5,6 . Two alternative

The formation of chalcone by the acid catalysed condensation of acetophenone and benzaldehyde has been studied 7,8. The rate of reaction is reported 7,8 to depend upon the first power of the concentration of acetophenone, and first power of the concentration of benzaldehyde and upon the Hammett acidity function. Also, the condensation step (vide infra) has been shown to be the rate determining step in this reaction. The following mechanism seems to be operable:

NOMENCLATURE: Benzylideneacetophenone is the parent member of the chalcone series. The substituents in the benzene rings of chalcone are numbered as shown, and follow the pattern adopted by the American Chemical Abstracts.



The alternative names 9 given to chalcone are: phenyl styryl ketone, benzalacetophenone, β -phenylacrylophenone, \forall -oxo- \ll , \forall -diphenyl- \ll -propylene, and \ll -phenyl- β -benzoylethylene.

References

- 1. Kostanecki, S.V. and Tambor, J., Chem. Ber., 32, 1921 (1899).
- 2. Kostanecki, S.V. and Rossbach, G., Chem. Ber., 29, 1488 (1896).
- 3. Coombs, E. and Evans, D.P., J. Chem. Soc., 1295 (1940).
- 4. Nikitin, E.K., J. Gen. Chem. USSR., 6, 1278 (1936).
- Nayak, P.L. and Rout, M.K., J. Indian Chem. Soc., <u>52</u>, 809 (1975).
- 6. Sipos, G., Fuka, A. and Szell, T., Monatsh. Chem., 91, 643 (1960).

- 7. Noyce, D.S. and Pryor, W.A., J. Am. Chem. Soc., <u>77</u>, 1397 (1955).
- 8. Noyce, D.S., Pryor, W.A. and Bottini, Λ.H., J. Am. Chem. Soc., <u>77</u>, 1402 (1955).
- 9. Beilstein, F., "Handbuch Der Organischen Chemie", Vierte Auflage, Band VII, 428 (1925).

CHAPTER - 2

SYNTHETIC METHODS

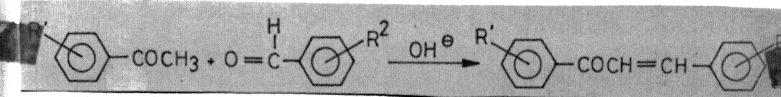
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By Claisen-Schmidt Reaction:

A variety of methods are available for the synthesis of chalcones (vide infra). The most convenient method is the one which involves Claisen-Schmidt condensation of equimolar quantities of a substituted acetophenone with substituted benzaldehyde in the presence of aqueous alcoholic alkali. 1-36



In the Claisen-Schmidt reaction, the concentration of alkali used usually range between 10-60%. 7.8,21,23,26 The reaction is carried out at about 50° for 12-15 hours, at room temperature for one week. 7 Under these conditions, however, Cannizzaro reaction 37 also takes place and thereby decreases the yield

of the desired product. In order to avoid the disproportionation of aldehyde in the above reaction, the use of benzylidene diacetate in place of aldehyde has been recommended. 38

Other condensing agents have been employed and include alkali metal alkoxide, 23,25,39 magnesium tert. butoxide, 40 potassium carbon compound, 41 (KC₈), hydrogen chloride, 42,43 anhydrous aluminium chloride, 44 boron trifluoride, 45 phosphorous oxychloride, 46 boric anhydride, 47 amino acids, 48 borax 49 and organocadmium compound, 50 e.g., CdEt, in butyl ether.

In the synthesis of polyhydroxy-chalcones by Claisen-Schmidt reaction, the higher concentration of alkali as a condensing agent is desirable. Chalcones having a 2'-hydroxy function, however, may cyclise to the corresponding flavanones under the above conditions. This difficulty has, however, been overcome by protecting the 2'-hydroxyl group of substituted acetophenone (as methoxymethyl ether) 121 before their reaction with aromatic aldehydes. This procedure is claimed 121 to provide a route to the synthesis of otherwise inacessible 2'-hydroxy chalcones.

The use of acid catalyst, HCl in preference to alkali, has been recommended, for example, in the synthesis of cyanomethyl chalcones, 42 as well as hydroxynitrochalcones. 43 2'-hydroxy-5-acetamido-chalcones have been synthesized involving the use of phosphorous oxychloride, which is claimed to be superior to alkali as a condensing agent. 47 Condensations have

been effected likewise in the presence of boric anhydride. 47
The water formed in this reaction is azeotropically distilled off with xylene. This method is reported to give good yield of chalcone. (-(phenylsulphonyl)) chalcones have been prepared 51 by the condensation of aromatic aldehydes with phenacyl phenyl sulphide and phenacyl sulphone respectively the condensing agents employed in these reactions consisted of glacial acetic acid in combination with an organic base, viz., piperidine or benzylamine.

Chalcone in 50% yield has also been prepared by the reaction of acetophenone and benzaldehyde under the conditions of the Perkin reaction. 122

From Chalcone & , B -dibromides:

Debromination of chalcone α , β -dibromide with one mole equivalent of trialkyl phosphine 52,54 yields chalcone in an excellent yield (92%). Triphenyl phosphine 53 likewise brings about debromination of the vicinal dibromo chalcone, thus:

$$\phi$$
COCHBr-CHBr ϕ + ϕ 3P - ϕ COCH = CH ϕ + ϕ 3PBr ϕ

From Schiff's Bases:

Schiff's bases are reported $^{57-59}$ to react with acetophenone and its derivative, in the presence of catalytic amount of amine hydrochloride, to yield β -arylaminoketone (I). On heating with concentrated hydrochloric acid, these ketones undergo the hydramine cleavage to yield primary aromatic amine and chalcone.

R-C6H4N=CH-C6H4-R'+ CH3COC6H4-R²

-R-C6H4-NH-CH(CH2COC6H4R²)C6H4R'

(I)

O

HCL

HV —RC6H4NH2 + R'C6H4CH=CH-C-C6H4-R²

withdrawing substituents in
$$\beta$$
-arylamine ketones.

From Organometallic Compounds:

(a) Chalcone in 20% yield has been secured from acetylenic Grignard reagent 61,123 by carrying it through the following

set is of transformations:

$$\phi C \equiv CMgX + n - C_4H_9O - CH - N - Me$$

$$\phi - C \equiv C - CH - N - Me$$

$$\phi - C \equiv C - CH - N - Me$$

$$\phi - CH = C = C(\phi)NMe - \frac{H_3O^{\circ}}{2} \phi - CH = CH - CO - \phi$$

$$(20\%)$$

The interaction of phenyl magnesium bromide and cinnamonitrile with ammonium chloride is reported to give an adduct, phenyl styryl ketimine dimer hydrochloride. The latter on hydrolysis, with dilute hydrochloric acid, furnished the chalcone.

Methyl magnesium iodide and benzaldehyde are reported⁶³ to react (in the absence of ether) to give chalcone, besides methyl phenyl carbinol. The formation of chalcone in this reaction arises due to the condensation of benzaldehyde with acetophenone formed by the oxidation of carbinol.

- (b) Chalcone has been secured⁶⁴ (65%) by the interaction of appropriate cadmium derivative and cinnamoyl chloride in refluxing ether.
- (c) The synthesis of chalcone (20-30%) has been achieved by the action of styryl cyanide with phenyl lithium. Alternatively, chalcone (33%) can be prepared by reacting transcinnamic acid by with phenyl lithium. Cis-cinnamic acid is reported to react more rapidly than the transcinner, yielding chalcone in a better yield (57%).
- (d) Phenylacetylene⁶⁶⁻⁶⁸ reacts with benzaldehyde, at room temperature, in the presence of BF₃ in ether, to give chalcone in 60% yield. The Lewis acid, BF₃, enhances the positive nature of the carbonyl carbon, thereby facilitates the reaction.

By Wittig Reaction:

Phosphorane of the general formula Me_nPh_(3-n)P=CHCOPh (n = 0,1,2,3) are reported⁶⁹⁻⁷¹ to react with benzaldehyde to yield chalcone in good yields (70-90%). A patent⁷² has appeared, which utilizes the Wittig reaction for the preparation of chalcone in 84% yield. Chalcone (60%) has also been obtained by the reaction of benzaldehyde with benzoylmethylene (p-dimethyl-aminophenyl) dimethyl phosphorane⁷³ or phosphonate carbanion,⁷⁴ II, derived from diethyl phenacyl phosphonate with sodium hydride:

hydride:

$$(2H_5O)_2 P - CHCO\phi + \phi - C - H - NaH/DME - \phi CH = CHCO\phi$$
(II)

Alternatively, 75 the potassium derivative of diethyl phenyl phosphonate is reacted with an aromatic aldehyde (in dry toluene) to yield the desired chalcone. Several substituted chalcones have been prepared 76 by the reaction of carbonyl stabilized phosphonium and arsonium ylides with o-hydroxybenzal-dehydes.

From Enamines and Aromatic Aldehydes:

The synthesis of chalcone has also been effected by the interaction of benzaldehyde with N-d-styryl morpholine. 77

From Oxidative Decarboxylation of Y-oxo Acids:

Lead dioxide is reported ⁷⁸ to bring about the oxidative decarboxylation of 3-benzoyl-2-phenylpropionic acid to yield chalcone.

COOH
$$\phi = \frac{COOH}{\rho + OCH} = \frac{PbO_2}{\rho + OCH} = CH \phi$$

By Photo-Fries Reaction 79-82:

Photo-Fries rearrangement of phenyl cinnamates 79,81,83 has been exploited for the synthesis of 2'-hydroxychalcone (20-50%). The same reaction has been extended to the synthesis of 2',3'-;2',4'- and 2',5'-dihydroxychalcones from the corresponding hydroxyphenyl cinnamates. 80 The synthesis of 2',3',5'-trihydroxychalcone has been achieved, 84 however, by the photolysis of 2,4-dihydroxycinnamate (the hydroxyl groups protected by methoxymethylation) followed by treatment with methanolic hydrochloric acid.

From Benzal Chloride and Acetophenone:

tional photographic and assistant victime

Chalcone, in 75% yield is reported⁸⁵ to be formed by heating at 120-130°, a mixture of benzal chloride and acetophenone in the presence of copper powder.

From Methyl Benzylphenacyl Sulphonium Hydroxide:

The synthesis of chalcone from methyl benzylphenacyl-sulphonium hydroxide⁸⁶ involves a number of synthetic steps, thus

From < -Diazoacetophenone:

Chalcone (8%) is reported to be formed when <-diazoaceto-phenone is subjected to thermal decomposition.87

From < -Epoxy Chalcones:

Chromous chloride in acetone medium brings about the reduction 88 of -epoxychalcone to give the corresponding chalcone in a low yield.

From Cinnamic Acid Anhydride:

Cadmium diphenyl⁸⁹ reacts with cinnamic acid anhydride to yield chalcone in 44% yield.

From Cinnamic Acid and Phenol:

Polyhydroxychalcones are obtained when cinnamic acid is condensed with phenols in presence of ${\rm BF}_3^{90-94}$ or polyphosphoric acid. 95

Alkylchalcones have been prepared, ⁹⁶ though in poor yield, by the reaction, for example, of 1,3,5-trihydroxyphenol with A-alkyl cinnamic acid, in the presence of acetic anhydride and polyphosphoric acid.

From Cinnamoyl Chloride and Benzene:

Chalcone (21%) along with 3-phenyl hydrindone (34%) are obtained ⁹⁷ by the interaction of cinnamoyl chloride with benzene, in the presence of anhydrous aluminium chloride. The yield of chalcone is reported to be quantitative if chlorobenzene is also added to the reaction mixture.

From Cinnamoyl Chloride and Phenol:

By using Behn's reaction polyhydroxychalcones have been synthesized.⁵ It consists in the reaction of polyhydric phenols with cinnamoyl chloride, in nitrobenzene solvent, using aluminium chloride as the condensing agent. With phloroglucinol, however the initially formed 2,4,6-trihydroxychalcone cyclises to give 5,7-dihydroxyflavanone as the major product. It is believed that 6'-hydroxyl activates the 2'-hydroxyl to bring about the cyclisation.

Cinnamoyl chloride has likewise been condensed with phenolic ethers 60,98,99 in carbon disulphide to give the corresponding chalcones. The Friedel-Crafts reaction of <u>cis</u>-cinnamoyl chloride with <u>n</u>-butyl ether of thiophenol is reported 100 to give $4'-(\underline{n}-butyl\ thio)$ chalcone.

From \$\beta_{\text{Benzoylacrylic Acids}}\$:

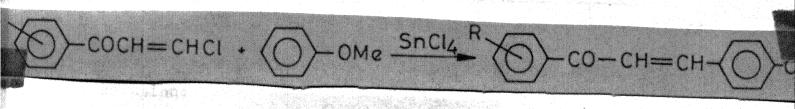
Aryl diazonium chlorides (carrying an electron withdrawing substituent) react with $\underline{\text{trans}}-\beta$ -benzoylacrylic acid 101,102 to give chalcones.

OCH=CHCOOH + ArN2CI - + ØCOCH=CHAr + N2+CO2+HC

The aryl group attacks the carbon atom ≪- to the carboxylic group and this initial coupling is followed by decarboxylation. 101

From eta -Chlorovinyl Ketones:

Substituted β -chlorovinyl ketones have been condensed with phenolic ethers 103-105 in presence of stannic chloride to give chalcones in fairly good yield (47-65%).



A variation of the above reaction consists in the interaction of β -chlorovinyl ketone with aromatic hydrocarbons ¹⁰³ and alkyl halides, ¹⁰³ under the influence of SnCl₄, to give the corresponding chalcones.

From Flavanones:

- (a) Treatment of flavanones with alkali results in the opening of Y-pyrone ring and formation of 2'-hydroxy-chalcone. 7,82,106-108 Thus satisfactory yield of 2'-hydroxy-4,4',6'-trimethoxychalcone has been obtained from 4',5,7-trimethoxyflavanone in the above manner.
- (b) The micro-organism, <u>Gibberella fukikuroi</u> is capable of cleaving the oxygen heterocycle of flavanone to yield 2'-hydroxychalcone. 109 Part of the substrate undergoes ring opening, followed by microbial oxidation to yield the 2',4-dihydroxychalcone.
- (c) UV irradiation of flavanone is reported 110 to yield three products, viz., 2'-hydroxychalcone (20%), 4-phenyldihydrocoumarin (13%) and salicylic acid (4%).

From 2-Diethylamino-1,3-Diphenyl-2-propen-1-one (III):

Chalcone (<u>cis</u> and <u>trans</u>) in 30% yield has been secured 111 by prolonged irradiation of the title compound in an ethereal solution:

$$\phi - C - C = CH - \phi$$

$$NEt_2 \quad (III)$$

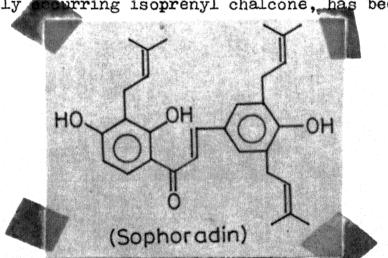
MISCELLANEOUS EXAMPLES:

Analogues of Carthamin:

The syntheses of two analogues of carthamin, viz., 3'methoxy-2',4,4',6'-tetrahydroxychalcone and 2'-methoxy-3',4,4',
6'-tetrahydroxychalcone are reported in the literature (cf.
Method I). The hydroxylic functions in the reactants are
protected by derivative preparation, viz., methoxymethylation,
and are regenerated by hydrolysis toward the end of reaction.

Sophoradin:

Based on the above reaction the synthesis of sophoradin, a naturally prepring isoprenyl chalcone, has been achieved. 113



An alternate way of sophoradin synthesis is outlined:

$$HC \equiv C - C - O \qquad OH \qquad + O = C - C = CH \frac{50\%}{NaOH}$$

$$(V) \qquad (IV)$$

$$HC \equiv C - C - O \qquad OH \qquad OH \qquad OH \qquad (IV)$$

$$HC \equiv C - C - O \qquad OH \qquad OH \qquad OH \qquad OH \qquad (IV)$$

$$Me \qquad (IV)$$

The starting materials (IV) and (V) are prepared as follows:

∠ -Aminochalcones:

The synthesis of d-amino chalcones have been achieved 115 by the following series of reactions:

$$CH = CH - CO \phi$$
 R
 $R = H, OCH_3)$
 $R = H + CH_3$
 $R = H + CH_3$

$$\begin{array}{c|c}
-CH_3OH & \bigcirc & +B^{\Theta} & \bigcirc & -CH^{-}C - C - \phi \\
\hline
R & H & O
\end{array}$$

$$\frac{-B^{9}}{R} - \frac{O}{R} - CH = C - C - \emptyset (R = H, OCH_{3})$$

$$\frac{O}{R} - \frac{O}{R} - \frac{O}{$$

MeÓ Ö nulmeott MeÓ O

Quinochalcones:

The synthesis of some quinochalcones has been achieved 117 by the oxidation of appropriately substituted hydroxychalcones. The preparation of 2',4,4'-trihydroxy-3',6'-quinochalcone serves as an illustrative example:

Chromenochalcones:

A method for the preparation of chromenochalcone is described, 118 and involves the following steps:

COCH = CH
$$\phi$$

CH₃Q

OH

CH₃Q

OCH₃

COCH = CH ϕ

Acetone

MeO

MeO

Me

MeO

MeO

MeO

\propto -Arylazo- β -arylchalcones:

Starting from \angle , β -diketoesters; \angle -arylazo- β -aryl-chalcones have been synthesized. Thus,

$$\begin{array}{c} CO \phi \\ Ar - NH - N = C - COOEt \\ \hline 2. H_2O \end{array}$$

$$\begin{array}{c} Ar NH - N = C - CO \phi \\ \hline 2. H_2O \end{array}$$

$$\begin{array}{c} \phi \\ Ar NH - N = C - CO \phi \\ \hline 0. N = N - Ar \end{array}$$

✓,2'-Diacetoxy-3,4,4',6'-tetramethoxychalcone:

The synthesis of , 2'-diacetoxy-3,4,4',6-tetramethoxychalcone from 2-benzyl-2-hydroxycoumaran-3-one (VI) is described. 120
Advantage is taken of the fact that the coumaranone in alkaline
medium exists in equilibrium with the corresponding chalcone classical (VII).

References

- 1. Kohler, E.P. and Chadwell, H.M., Organic Synthesis Coll., Vol. II, 1 (1922).
- 2. Schraufstatter, E. and Deutsch, S., Chem. Ber., 81, 489 (1948).
- 3. Smith, H.E. and Paulson, M.C., J. Am. Chem. Soc., <u>76</u>, 4486 (1954).
- 4. Obara, H., Onodera, J. and Kurihara, Y., Bull. Chem. Soc. Japan, 44, 289 (1971).
- Shinoda, J. and Sato, S., J. Pharm. Soc. (Japan), 48, 791 (1928); Chem. Abstr., 23, 836⁶ (1929).
- 6. Kurth, E.F., J. Am. Chem. Soc., 61, 861 (1939).
- 7. Geissman, T.A. and Clinton, R.O., J. Am. Chem. Soc., <u>68</u>, 697 (1946).

- 8. Martin, G.J., Beiler, J.M. and Avakian, S., U.S. Patent 2,769,817 (1956); Chem. Abstr., <u>51</u>, 14815^d (1957).
- 9. Jurd, L. and Horowitz, R.M., J. Org. Chem., 26, 2561 (1961).
- 10. Starkov, S.P., Panasenko, A.I. and Volkotrub, M.N., Izv. Vyssh., Uched. Zaved., Khim. Khim. Tekhnol., <u>12</u>, 1072 (1969); Chem. Abstr., 72, 66738^q (1970).
- 11. Vyas, G.N. and Shah, N.M., J. Indian Chem. Soc., <u>28</u>, 75 (1951).
- 12. Matsuura, S. and Matsuura, A., Yakugaku Zasshi, <u>77</u>, 330 (1957); Chem. Abstr., <u>51</u>, 11300ⁱ (1957).
- 13. Raval, A.A. and Shah, N.M., J. Org. Chem., 22, 304 (1957).
- 14. Shah, N.M. and Parikh, S.R., J. Indian Chem. Soc., <u>36</u>, 726 (1959).
- 15. Dhar, D.N., J. Indian Chem. Soc., 37, 363 (1960).
- 16. Boichard, J. and Tirouflet, J., Compt. Rend., <u>251</u>, 1394 (1960).
- 17. Satpathi, P.S. and Trivedi, J.P., Current Sci. (India), 29, 429 (1960).
- 18. Szell, T., Indian J. Chem., 6, 470 (1960).
- 19. Weber, F-G., Rinow, A. and Seedorf, C., Z. Chem., 9, 380 (1969).
- 20. Hsu, K.K., Lo, M.S. and Chen, F.C., J. Chin. Chem. Soc. (Taipei), <u>16</u>, 91 (1969); Chem. Abstr., <u>72</u>, 31393^W (1970).
- 21. Falcao da Fonseca, L., Bol. Fac. Farm., Univ. Coimbra, Ed. Cient, <u>28</u>, 49 (1968); Chem. Abstr., <u>72</u>, 121124^p (1970).

- 22. Chen, F-C. and Chang, P-W., Tai-Wan K'O Hsueh, <u>24</u>, 105 (1970); Chem. Abstr., 75, 19859^g (1971).
- 23. Fujise, S. and Tatsuta, H., J. Chem. Soc. Japan, <u>63</u>, 932 (1942).
- 24. Hamada, M., Botyu-Kayaku, <u>21</u>, 22 (1956); Chem. Abstr., <u>51</u>, 3519^d (1957).
- 25. Széll, T. and Bajusz, S., Magyar Kém. Folyóirat, <u>61</u>, 235 (1955); Chem. Abstr., <u>52</u>, 9048^g (1958).
- 26. Tsukerman, S.V., Chang, K-S. and Lavrushin, V.F., Zh. Obshch. Khim., 34, 2881 (1964).
- 27. Dhar, D.N. and Singh, R.K., J. Indian Chem. Soc., <u>48</u>, 83 (1971).
- 28. Loth, H. and Worm, G., Arch. Pharm. (Weinheim), 301, 897 (1968); Chem. Abstr., 70, 68064² (1969).
- 29. Biletch, H.A. and Rajunas, J.V. (Jr.), U.S. Patent, 3,361,827 (1968); Chem. Abstr., <u>68</u>, 104756 (1968).
- 30. Shah, P.R. and Shah, N.M., Current Sci. (India), 31, 12 (1962).
- 31. Lespagnol, Λ., Lespagnol, C., Lesieur, D., Bonte, J.P., Blain, Y. and Labiau, O., Chim. Ther., <u>6</u>, 192 (1971); Chem. Abstr., <u>75</u>, 98285^t (1971).
- 32. Bargellini, G. and Martegiani, E., Gazz. Chim. Ital., 42, II, 427.
- 33. Lavrushin, V.F. and Verkhovod, N.N., Zh. Organ. Khim.,
 1(7), 1220 (1965); Chem. Abstr., 63, 13118^b (1965).

- 34. Wolf, V.L. and Troltzsch, C., J. Prakt. Chem., <u>17</u>, 69 (1962).
- 35. Hayakawa, G. and Inoue, T., Japanese Patent, 7107,386 (1971); Chem. Abstr., 74, 143332 (1971).
- 36. Pomerantseva, L.L., Smirnova, G.A. and Oleinik, A.V., Tr. Khim. Khim. Tekhnol., (1), 14 (1972); Chem. Abstr., <u>78</u>, 159099^W (1973).
- 37. Dhar, D.N. and Lal, J.B., J. Org. Chem., 23,1159 (1958).
- 38. Davey, W. and Gwilt, J.R., J. Chem. Soc., 1008 (1957).
- 39. Gilman, H. and Cason, L.F., J. Am. Chem. Soc., <u>72</u>, 3469 (1950).
- 40. Guthrie, J.L. and Rabjohn, N., J. Org. Chem., <u>22</u>, 176 (1957).
- 41. Rochus, W., Kickuth, R., German Patent, 1,095,832 (1957); Chem. Abstr., <u>56</u>, 10976 (1961).
- 42. Rorig, K.J., U.S. Patent 2,755,299 (1956); Chem. Abstr., 51, 2868^c (1957).
- 43. Sipos, G., Dobo, I. and Czukor, B., Acta Phys. et Chem. Szeged, 8, 160 (1962); Chem. Abstr., 59, 5059^g (1963).
- 44. Calloway, N.O. and Green, L.D., J. Am. Chem. Soc., <u>59</u>, 809 (1937).
- 45. Breslow, D.S. and Hauser, C.R., J. Am. Chem. Soc., <u>62</u>, 2385 (1940).
- 46. Raval, A.A. and Shah, N.M., J. Sci. Ind. Res. (India), <u>21B</u>, 234 (1962).

- 47. Kuskov, V.K. and Utenkova, G.N., Zh. Obshch. Khim., <u>29</u>, 4030 (1959).
- 48. Reichel, L., Naturwissenschaften, 32, 215 (1944).
- 49. Jadhav, G.V. and Kulkarni, V.G., Current Sci. (India), <u>20</u>, 42 (1951).
- 50. Gilman, H. and Nelson, J.F., Rec. Trav. Chim., <u>55</u>, 518 (1936).
- 51. Balaiah, V. and Natarajan, C., Indian J. Chem., <u>8</u>, 694 (1970).
- 52. Dershowitz, S. and Proskauer, S., J. Org. Chem., <u>26</u>, 3595 (1961).
- 53. Hoffmann, H. and Diehr, H.J., Tetrahedron Letters, 583 (1962).
- 54. Dershowitz, S., U.S. Patent, 3,104,257 (1963); Chem. Abstr., 60, P 2848^f (1964).
- 55. Julian, P.L., Cole, W., Magnani, A. and Meyer, E.W., J. Am. Chem. Soc., 67, 1728 (1945).
- 56. Bickel, C.L., J. Am. Chem. Soc., 72, 349 (1950).
- 57. Kozlov, N.S., Pinegina, L.Y. and Selezneva, E.A., Zh. Obshch. Khim., 32, 436 (1962).
- 58. Kozlov, N.S., Pak, V.D. and Simonova, E.V., Vestsi Akad.

 Nauk Belarus, SSR, Ser. Khim. Nauk, (4), 111 (1968);

 Chem. Abstr., 70, 77514 (1969).
- 59. Kozlov, N.S. and Shur, I.A., Zh. Obshch. Khim., 29, 2706 (1959).
- 60. Monti, L., Gazz. Chim. Ital., 60, 43 (1930).

- 61. Normant, H. and Mantione, R., Compt. Rend., <u>259</u>, 1635 (1964).
- 62. Henze, H.R. and Swett, L.R., J. Am. Chem. Soc., <u>73</u>, 4918 (1951).
- 63. Tarbell, D.S. and Paulson, M.C., J. Am. Chem. Soc., <u>64</u>, 2842 (1942).
- 64. Langlais, M., Buzas, A., Soussan, G. and Freon, P., Compt. Rend., 261, 2920 (1965).
- 65. Bond, J.C. and Wright, G.F., J. Am. Chem. Soc., <u>72</u>, 1023 (1950).
- 66. Arens, J.F., Tjakob, H.J. and Vieregge, H., U.S. Patent 3,030,359 (1962); Chem. Abstr., 57, 11024^h (1962).
- 67. Vieregge, H., Bos, H.J.T. and Arens, J.F., Rec. Trav. Chim., 78, 664 (1959).
- 68. Bos, H.J.T. and Arens, J.F., Rec. Trav. Chim., <u>82</u>, 845 (1963).
- 69. Bestmann, H.J. and Arnason, B., Chem. Ber., 95, 1513 (1962).
- 70. Trippett, S. and Walker, D.M., Chem. and Ind. (London), 933 (1960).
- 71. Trippett, S. and Walker, D.M., J. Chem. Soc., 1266 (1961).
- 72. Bestman, H.J. and Kratzer, O., German Patent 1,256,642 (1967); Chem. Abstr., 69, 52933^a (1968).
- 73. Trippett, S. and Walker, D.M., J. Chem. Soc., 2130 (1961).
- 74. Wadsworth, W.S. (Jr.) and Emmons, W.D., J. Am. Chem. Soc., 83, 1733 (1961).

- 75. Grinev, G.V., Chervenyuk, G.I. and Dombrovskii, A.V., Zh. Obshch. Khim., 38, 225 (1968).
- 76. Bravo, P., Tricozzi, C. and Cezza, A., Gazz. Chim. Ital., 105, 109 (1975).
- 77. Birkofer, L., Kim, S.M. and Engels, H.D., Chem. Ber., <u>95</u>, 1495 (1962).
- 78. Hertzler, D.V., Berdahl, J.M. and Eisenbraun, E.J., J. Org. Chem., 33, 2008 (1968).
- 79. Ramakrishnan, V.T. and Kagan, J., J. Org. Chem., <u>35</u>, 2901 (1970).
- 80. Obara, H., Takahashi, H. and Hirano, H., Bull. Chem. Soc. Japan, 42, 560 (1969).
- 81. Obara, H., Takahashi, H. and Onodera, J., Kogyo Kagaku Zasshi, <u>72</u>, 309 (1969); Chem. Abstr., <u>71</u>, 12758^g (1969).
- 82. Wilson, C.W., U.S. Patent 2,425,291 (1947); Chem. Abstr., 41,6674° (1947).
- 83. Bhatia, V.K. and Kagan, J., Chem. and Ind. (London), 1203 (1970).
- 84. Onodera, J. and Obara, H., Bull. Chem. Soc. (Japan), <u>47</u>, 240 (1974).
- 35. Tsukervanik, I.P. and Galust'yan, G.G., Zh. Obshch. Khim., 31, 528 (1961).
- 86. Ruiz, E.B., Acta Salmenticensia, Ser. Cienc., 2, No. 7, 64 (1958); Chem. Abstr., 54, 7624^b (1960).
- 87. Yates, P. and Clark, T.J., Tetrahedron Letters, 435 (1961).

- 88. Julian, P.L. and Cole, J.W., U.S. Patent 3,055,918 (1962); Chem. Abstr., 58, P 5767^d (1963).
- 89. Nightingale, D. and Wadsworth, F., J. Am. Chem. Soc., <u>67</u>, 416 (1943).
- 90. Mani, R. and Venkataraman, K., Current Sci. (India), <u>23</u>, 220 (1954).
- 91. Starkov, S.P. and Panasenko, A.I., Zh. Organ. Khim., 7, 1463 (1971); Chem. Abstr., 75, 129462^e (1971).
- 92. Starkov, S.P., Panasenko, A.I. and Volkotrub, M.N., Izv.

 Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., 15, 866 (1972);

 Chem. Abstr., 77, 114191h (1972).
- 93. Starkov, S.P., Panasenko, A.I. and Volkotrub, M.N., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., 16, 895 (1973); Chem. Abstr., 79, 91907 (1973).
- 94. Starkov, S.P., Starkova, S.K. and Goncharenko, G.A., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., <u>20</u>, 1149 (1977); Chem. Abstr., <u>88</u>, 22272^j (1978).
- 95. Reichel, L. and Proksch, G., Justus Liebigs Ann. Chem., 745, 59 (1971).
- 96. Hasebe, N., Nippon Kagaku Zasshi, <u>89</u>, 534 (1968); Chem.

 Abstr., 70, 3455^h (1969).
- 97. Rasschaert, Λ., Janssens, W. and Slootmaekers, P.J., Bull. Soc. Chim. Belges., <u>75</u>, 449 (1966); Chem. Abstr., <u>66</u>, 2305^e (1967).
- 98. Bodani, D.C., Bodani, V.V. and Wheeler, T.S., Current Sci. (India), <u>6</u>, 604 (1938).

- 99. Bargellini, G. and Finkelstein, M., Gazz. Chim. Ital., <u>42</u>, II, 417.
- 100. Velarde, E., Hammond, G. and Hoet, P., Bol. Soc. Quim. Peru, <u>41</u>, 133 (1975); Chem. Abstr., <u>85</u>, 123504^e (1976).
- 101. Mehra, H.S. and Mathur, K.B.L., J. Indian Chem. Soc., <u>32</u>, 465 (1955).
- 102. Mehra, H.S. and Mathur, K.B.L., J. Indian Chem. Soc., 33, 618 (1956).
- 103. Kochetkov, N.K. and Belyaev, V.F., Zh. Obshch. Khim., 30, 1495 (1960).
- 104. Belyaev, V.F., Yatsevich, N.M. and Sokolov, N.A., Zh. Obshch. Khim., 32, 2022 (1962).
- 105. Belyaev, V.F., Zh. Obshch. Khim., 34, 861 (1964).
- 106. Bargellini, G. and Monti, L., Gazz. Chim. Ital., <u>44</u>, II, 24 (1914).
- 107. Linke, H.A.B. and Eveleigh, D.E., Z. Naturforsch., <u>30B</u>, 606 (1975).
- 108. Linke, H.A.B. and Eveleigh, D.E., Z. Naturforsch., 30B, 940 (1975).
- 109. Udupa, S.R., Banerji, A. and Chadha, M.S., Tetrahedron, 25, 5415 (1969).
- 110. Mack, P.O.L. and Pinhey, J.T., Chem. Commun., (8), 451 (1972).
- 111. Arnould, J.C. and Pete, J.P., Tetrahedron Letters, 2459 (1975).

- 112. Obara, H., Onodera, J. and Abe, S., Chem. Letters, 335 (1974).
- 113. Kyogoku, K., Hatayama, K., Yokomori, S., Seki, T. and Tanaka, I., Agric. Biol. Chem., <u>39</u>, 133 (1975); Chem. Abstr., <u>82</u>, 156524^c (1975).
- 114. Kyogoku, K., Hatayama, K., Yokomori, S., Seki, T. and Tanaka, I., Agric. Biol. Chem., <u>38</u>, 2291 (1974); Chem. Abstr., 82, 97789^t (1975).
- 115. Reichel, L. and Pritze, P., Justus Liebigs Ann. Chem., 120 (1974).
- 116. Fourie, T.G., Ferreira, D. and Roux, D.G., Chem. Commun., 760 (1974).
- 117. Obara, H. and Onodera, J., Chem. Letters, 1357 (1974).
- 118. Mathur, A.K., Mathur, K.B.L. and Seshadri, T.R., Indian J. Chem., <u>11</u>, 1231 (1973).
- 119. Harhash, A.H., Mansour, A.K., Elnagdi, M.H. and Elmoghayar, M.R.H., J. Prakt. Chem., 315, 235 (1973).
- 120. Clark-Lewis, J.W. and Jemison, R.W., Aust. J. Chem., <u>21</u>, 815 (1968).
- 121. Rall, G.J.H., Overholzer, M.E., Ferreira, D. and Roux, D.G., Tetrahedron Letters, 1033 (1976).
- 122. Stanek, J. and Horák, M., Coll. Czech. Chem. Commun., <u>15</u>, 1037 (1951).
- 123. Normant, H. (Societe des Usines Chimiques Rhone-Poulene)
 French Patent 1,411,091 (1965); Chem. Abstr., 64, 3426^e
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CHAPTER - 3

SOME CLASSES OF CHALCONES AND CHALCONE ANALOGUES

Substituted Chalcones

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SUBSTITUTED CHALCONES

Hydroxynitrochalcones:

Several hydroxynitrochalcones 1-11 have been prepared involving the Claisen-Schmidt condensation. This condensation has been effected with a variety of condensing agents, viz., aqueous alkali, 12-17 sodium methylate, piperidine, 14 aluminium chloride, 12,14,18 boron trifluoride, 14 and dry hydrogen chloride. The preparation of a methylchalcones (containing a nitro group) by the interaction of hydroxynitropropiophenone

with various aldehydes is also reported in the literature. 19 It has been suggested 20 that dypnones may be the possible intermediates in the synthesis of nitrohydroxychalcones.

In general the electron donating substituents ¹⁶ (low Hammett Constant) in the aldehydic component, and the electron withdrawing substituents (high Hammett constant) in the ketone, ²¹ favour the Claisen-Schmidt condensation by HCl. On the other hand the electron withdrawing substituent ¹⁵ in the aldehydic component, favour condensation by caustic alkali.

The preparation of a large number of substituted chalcones, which include hydroxy-, methoxy- and carboxychalcones are reported 22-48 in the literature.

Hydroxychalcones:

Some of the difficultly preparable 2'-hydroxychalcones have been synthesized in excellent yields, by converting the 2-hydroxy group of 2-hydroxyacetophenone to corresponding methoxymethyl ether, 49 prior to Claisen-Schmidt condensation. The hydroxychalcone is then regenerated by treatment with hot acid.

The synthesis of chalcones derived from 2-hydroxy acetophenone, 50 2'-hydroxy-4-ethoxyacetophenone, 51 2-hydroxy-4-n-butoxyacetophenone 52 and 2-hydroxy-4-n-propoxy-5-bromo (or nitro)-acetophenone 53-55 have also been reported. The preparation of polyhydroxychalcones derived from resacetophenone 32,56 and quinacetophenone 57 has been secured likewise.

The reaction of p-hydroxybenzaldehyde with substituted acetophenone is claimed ⁵⁸ to proceed well in acid than in alkaline medium. This observation has been rationalised ⁵⁸ as follows: In alkaline medium, reaction (i) is favoured, which obviously lowers the reactivity of the carbonyl carbon and hence does not lead to

HO
$$\longrightarrow$$
 C \longrightarrow H \longrightarrow HO \longrightarrow C \longrightarrow C \longrightarrow H \longrightarrow HO \longrightarrow C \longrightarrow C \longrightarrow H

In acid medium, however, the dissociation of the phenol is restricted and the formation of carbonium ion (I) is facilitated. These effects, therefore, exert a favourable influence of chalcone formation.

Methoxychalcones:

The syntheses of a large number of methoxychalcones, 59,60 including those derived, from quinacetophenone monomethyl ether 61 and resacetophenone dimethyl ether, 56 are described in literature.

Carboxychalcones and Chalcone Analogues:

Carboxychalcones, 62,63 including the chalcone derived from caffeic acid have been prepared by the usual Claisen-Schmidt reaction. In general the ketone required in the reaction are derived by the Fries migration of o- and p-acetoxybenzoic acids.

The naphthalene, 65-72 phenanthrene, 66 anthracene 66 and bicyclic 73 analogue of chalcones have also been prepared.

Isopatylchalcones:

The synthesis of several naturally occurring isopertyl chalcones 74,75 have been accomplished by employing Claisen-Schmidt reaction, viz., cordoin, 75 isocordoin, 75 4-hydroxycordoin, 75 derricin, 75,77 4-hydroxyderricin, 75 sophoradin, 76 and derricidin. 77

Phosphorylated and Sulphuric Acid Esters of Chalcones:

The preparation of title compounds 78,79 have been achieved by Claisen-Schmidt reaction

Phenylchalcones:

The synthesis of 4- (and 4'-) phenylchalcones 80 and < - (and β -) phenylchalcones $^{81-83}$ are described in the literature.

The preparation of d_-phenylchalcone
has been secured
by the interaction of appropriately substituted acrylyl chloride
with phenol in the presence of aluminium chloride. On the other
hand 4'-nitrod_-phenylchalcone has been obtained
by the

reaction of 4'-nitrodesoxybenzoin with ethyl benzylideneacetoacetate under the influence of ethanolic sodium methoxide.

Polyfluorochalcones:

The polyfluorochalcones (II-IV) have been synthesized by the Claisen-Schmidt reaction:

R-CH=CHCOR'

II
$$R=C_6F_5$$
; $R'=C_6H_5$

III
$$R=C_6H_5$$
; $R'=C_6F_5$

IV
$$R=C_6F_5$$
; $R'=C_6F_5$

In the synthesis of IV, a lower concentration of alkali (1.5%) has been recommended. With higher concentration of alkali, the initially formed polyfluorochalcone undergoes a haloform type of cleavage leading to the formation of 2,3,4,5,6-pentafluorotrans-cinnamic acid and pentafluorobenzene.

Heterocyclic Chalcone Analogues:

A number of heterocyclic analogues of chalcones have been reported. These include the chalcone analogues of pyrrole, 85,87 indole, 88,89 carbazole, 90 furan, 67,85,86,91-95, thiophene, 66,85,92,96-103 selenophene, 104 pyridine, 66,92,93,98,105-107 quinoline, 66,93 8-hydroxyquinoline, 108 piperidine, 109 1,4-benzodioxans, 110 pyridone, 111 pyrimidine, 112 pyrazole 113 and acridine. 114

Several chalcone analogues have been prepared by the Claisen-Schmidt reaction, viz., ferrocene, 115,116 cymantrene, 117 benzo-chrotrene, 117 cinnamoyl 118 chromono, 122 chromeno 123,124 and coumarinochalcones. 119

The syntheses of chromenochalcone 120 including Flemi-Chapparin A have been achieved (53-63%) by the reaction of 6-acetyl-5,8-dihydroxy-2,2-dimethylchromene (V) and substituted benzaldehydes:

The preparation of some a-aroylchalcones involving
Knoevenagel reaction between diaroylmethanes and aromatic
aldehydes has also been described.

References

- 1. Tanasescu, I. and Baciu, A., Bull. Soc. Chim. [5], 4, 1742 (1937); Chem. Abstr., 32, 1674 (1938).
- Kulkarni, V.G. and Jadhav, G.V., J. Univ. Bombay, <u>22A</u>,
 Part 5, No. 35, 17 (1954); Chem. Abstr., <u>49</u>, 11590^c (1955).
- Széll, T. and Bajusz, S., Magyar Ke'm. Folyóirat, <u>60</u>, 5
 (1954); Chem. Abstr., 52, 5352^g (1958).
- 4. Chhaya, G.S., Trivedi, P.L. and Jadhav, G.V., J. Univ. Bombay, <u>26A</u>, Part 3, 16 (1957); Chem. Abstr., <u>53</u>, 10125^a (1959).
- 5. Chhaya, G.S., Trivedi, P.L. and Jadav, G.V., J. Univ. Bombay, <u>27A</u>, Part 3, 26 (1958); Chem. Abstr., <u>54</u>, 8807⁶ (1960).
- 6. Seshadri, S. and Trivedi, P.L., J. Org. Chem., <u>22</u>, 1633 (1957).
- 7. Dhar, D.N., J. Org. Chem., 25, 1247 (1960).
- 8. Price, D. and Bogert, M.T., J. Am. Chem. Soc., <u>56</u>, 2442 (1934).
- 9. Széll, T., Magyar Ke'm. Folyórirat, <u>64</u>, 44 (1958); Chem. Abstr., <u>52</u>, 14577^c (1958).
- 10. Széll, T., Chem. Ber., 93, 1928 (1960).
- 11. Wagh, S.P. and Jadhav, G.V., J. Univ. Bombay, <u>27A</u>, Part
 3, 1 (1958); Chem. Abstr., <u>54</u>, 8723^b (1960).
- 12. Széll, T., Chem. Ber., 92, 1672 (1959).
- 13. Sipos, G., Széll, T. and Va'rnai, I., Acta Phys. et Chem. Szeged., <u>6</u>, 109 (1960); Chem. Abstr., <u>55</u>, 14377^c (1961).

- 14. Szell, T. and Sipos, G., Ann., 641, 113 (1961).
- 15. Széll, T. and Sohár, I., Can. J. Chem., 47, 1254 (1969).
- 16. Széll, T. and Sohár, I., Acta Chim. (Budapest), <u>62</u>, 429 (1969).
- 17. Széll, T., Dudas, T. and Zarandy, M.S., Acta Phys. et Chem. Szeged., <u>15</u>, 157 (1969); Chem. Abstr., <u>73</u>, 3618^a (1970).
- 18. Sipos, G. and Szell, T., Acta Univ. Acta Phys. et Chem. Szeged., <u>5</u>, 70 (1959); Chem. Abstr., <u>54</u>, 10951^d (1960).
- 19. Széll, T., J. Prakt. Chem., 17, 346 (1962).
- 20. Sipos, G. and Széll, T., Naturwissenschaften, 46, 532 (1959).
- 21. Sipos, G., Csch, I. and Kalmar, A., Acta Phys. Chem. Szeged., <u>16</u>, 45 (1970); Chem. Abstr., <u>73</u>, 119961^m (1970).
- 22. Kulkarni, V.G. and Jadhav, G.V., J. Indian Chem. Soc., 31, 746 (1954).
- 23. Kulkarni, V.G. and Jadhav, G.V., J. Indian Chem. Soc., 32, 97 (1955).
- 24. Patel, C.C. and Shah, N.M., J. Indian Chem. Soc., 31, 867 (1954).
- 25. Atchabba, F.A., Trivedi, P.L. and Jadhav, G.V., J. Indian Chem. Soc., <u>32</u>, 206 (1955).
- 26. Davey, W. and Gwilt, J.R., J. Chem. Soc., 1008 (1957).
- Kulkarni, V.G. and Jadhav, G.V., J. Univ. Bombay, <u>23Δ</u>,
 14 (1965); Chem. Abstr., <u>51</u>, 11301^d (1957).

- 28. Raval, A.A. and Shah, N.M., J. Org. Chem., 21, 1408 (1956).
- 29. Buu-Hoi, N.P., Sy, M. and Riche, J., J. Org. Chem., <u>22</u>, 668 (1957).
- 30. Chhaya, G.S., Trivedi, P.L. and Jadhav, G.V., J. Univ. Bombay, <u>25</u>, 8 (1957); Chem. Abstr., <u>52</u>, 14598^h (1958).
- 31. Atchaba, F.A., Trivedi, P.L. and Jadhav, G.V., J. Univ. Bombay, <u>25</u>, 1 (1957); Chem. Abstr., <u>52</u>, 14599ⁱ (1958).
- 32. Dhar, D.N. and Lal, J.B., J. Org. Chem., <u>23</u>, 1159 (1958).
- 33. Szcll, T., Chem. Ber., 91, 2609 (1958).
- 34. Chhaya, G.S., Trivedi, P.L. and Jadhav, G.V., J. Univ. Bombay, <u>26A</u>, 22 (1958); Chem. Abstr., <u>53</u>, 14038^h (1959).
- 35. Wagh, S.F. and Jadhav, G.V., J. Univ. Bombay, <u>261</u>, 28 (1958); Chem. Abstr., <u>53</u>, 14097^c (1959).
- 36. Wagh, S.P. and Jadhav, G.V., J. Univ. Bombay, <u>261</u>, 4 (1958); Chem. Abstr., <u>53</u>, 14098^b (1959).
- 37. Raut, K.B., Dissertation Abstr., 20, 97 (1959).
- 38. Atchabba, F.A., Trivedi, P.L. and Jadhav, G.V., J. Univ. Bombay, <u>271</u>, 8 (1958); Chem. Abstr., <u>54</u>, 9907⁶ (1960).
- 39. Mulchandani, N.B. and Shah, N.M., Chem. Ber., <u>93</u>, 1918 (1960).
- 40. Awad, W.I., Neweihy, F.F.E. and Selim, S.F., J. Org. Chem., 25, 1333 (1960).
- 41. Klinke, P. and Gibian, H., Chem. Ber., 94, 26 (1961).
- 42. Dhar, D.N., J. Indian Chem. Soc., 37, 799 (1960).
- 43. Dhar, D.N., J. Indian Chem. Soc., 38, 823 (1961).

- 44. Merchant, J.R. and Choughuley, A.S.U., Chem. Ber., <u>95</u>, 1792 (1962).
- 45. Scikel, M.K., Lounsbury, M.J. and Wang, S.C., J. Org. Chem., <u>27</u>, 2952 (1962).
- 46. Jacob, K.C., Jadhav, G.V. and Vakharia, M.N., Pesticides, <u>6</u>, 94 (1972); Chem. Abstr., <u>78</u>, 147867^g (1973).
- 47. Shah, P.R. and Shah, N.M., Chem. Ber., 97, 1453 (1964).
- 48. Wagner, G., Griessmann, R. and Ritchter, P., Pharmazie, 34. 65 (1979).
- A9. Rall, G.J.H., Oberholzer, M.E., Ferreira, D. and Roux, D.G., Tetrahedron Letters, 1033 (1976).
- Dubnitskaya, V.I., Oganesyan, E.T., Shinkarenko, A.L., Izv. Sev. Kavk. Nauchn. Tsentra Vyssh Shk., Ser. Estestv. Nauk, 3, 74 (1975); Chem. Abstr., 83, 205884b (1975).
- 51. Joshi, R.S. and Naik, H.B., J. Inst. Chem. (India), <u>50</u>, 153 (1978).
- 52. Mankiwala, S.C., Naik, H.B. and Thakor, V.M., J. Indian Chem. Soc., 52, 560 (1975).
- 53. Mankiwala, S.C., Naik, H.B. and Thakor, V.M., J. Inst. Chem. (India), 47, 132 (1975).
- 54. Shah, N.J., Jhaveri, L.C. and Naik, H.B., J. Inst. Chem. (India), 49, 204 (1977).
- 55. Shah, N.J., Jhaveri, L.C. and Naik, H.B., J. Inst. Chem. (India), 50, 171 (1978).
- 56. Lal, J.B., J. Indian Chem. Soc., 16, 296 (1939).

- 57. Vyas, G.M. and Shah, N.M., J. Indian Chem. Soc., <u>26</u>, 273 (1949).
- 58. Sipos, G. and Sirokman, F., Nature, 202 (4931), 489 (1964).
- 59. Kuroda, C. and Matsukuma, T., Sci. Papers Inst. Phys. Chem. Research (Tokyo), <u>18</u>, 51 (1932); Chem. Abstr., <u>26</u>, 2442⁸ (1932).
- 60. Kuroda, C. and Nakamura, T., Sci. Papers Inst. Phys. Chem. Research (Tokyo), <u>18</u>, 61 (1932); Chem. Abstr., <u>26</u>, 2442⁸ (1932).
- 61. Vyas, G.N. and Shah, N.M., Current Sci. (India), 19, 318 (1950).
- 62. Shah, D.N. and Shah, N.M., J. Indian Chem. Soc., <u>26</u>, 235 (1949).
- 63. Vyas, G.N. and Shah, N.M., J. Indian Chem. Soc., <u>28</u>, 41 (1951).
- 64. Cahn, J. and Wermuth, C.G., French Patent 1,583,930; Chem. Abstr., 73, 76884^u (1970).
- 65. Belyaev, V.F., Abrazhevich, A.I. and Vasilevish, I.F.,
 Vestsi Akad. Nauk Belarus SSR, Ser. Khim. Nauk, (1), 116
 (1971); Chem. Abstr., 74, 125243^r (1971).
- 66. Raut, K.B. and Wender, S.H., J. Org. Chem., 25, 50 (1960).
- 67. Tewari, S.S. and Singh, A., J. Indian Chem. Soc., <u>38</u>, 931 (1961).
- 68. Misra, S.S. and Dinkar, J. Indian Chem. Soc., <u>49</u>, 725 (1972).

- 69. Wagh, S.P. and Jadhav, G.V., J. Univ. Bombay, <u>251</u>, 23 (1957); Chem. Abstr., 52, 7304^h (1958).
- 70. Deshmukh, G.V. and Wheeler, T.S., J. Chem. Soc., 96 (1939).
- 71. Mitina, V.G., Zadorozhnyi, B.A., Vestn-Kharkov un-ta Khimiya, 115, 108 (1974); Chem. Abstr., <u>83</u>, 114046^p (1975).
- 72. Yuldashev, K.Y., Dokl. Akad. Nauk Uzb. SSR (12), 35 (1977); Chem. Abstr., 91, 74372^y (1979).
- 73. Raikova, T.S., Vestsi Akad. Nauk Belarus, SSR, Ser. Khim. Nauk, (3), 128 (1973); Chem. Abstr., 79, 65949⁸ (1973).
- 74. Kyogoku, K., Hatayama, K., Yokomori, S. and Seki, T., Japanese Patent 74,126,654 (1974); Chem. Abstr., <u>83</u>, 78864^t (1975).
- 75. Lupi, A., Delle Monache, G., Delle Monache, F., Marini-Bettolo, G.B., Goncalves de Lima, O. and De Mello, J.F., Farmaco, Ed. Sci., 30, 449 (1975); Chem. Abstr., 83, 178450^y (1975).
- 76. Kyogoku, K., Hatayama, K., Yokomori, S., Seki, T. and Tanaka, I., Agric. Biol. Chem., <u>39</u>, 667 (1975); Chem. Abstr., 83, 28382^p (1975).
- 77. Khanna, R.N., Khanna, P.L., Manchanda, V.P. and Seshadri, T.R., Indian J. Chem., 11, 1225 (1973).
- 78. Bergl, F., Cohen, A., Haworth, J.W. and Hughes, E.G., U.S. Patent, 2,465,320 (1949); Chem. Abstr., 43, 6235^h (1949).
- 79. Yamaguchi, K., Nippon Kagaku Zasshi, 84, 148 (1963).
- 80. Hsu, K.K., Wu, T.S. and Shi, J.Y., J. Chin. Chem. Soc. (Taipei), 19, 45 (1972); Chem. Abstr., 77, 74967^g (1972).

- 81. Offe, H.A., Chem. Ber., 80, 449 (1947).
- 82. Vorlander, D., Osterburg, J. and Meye, O., Chem. Ber., <u>56B</u>, 1136 (1923).
- 83. Buza, D. and Gryff-Keller, A., Rocz. Chem., <u>43</u>, 1945 (1969); Chem. Abstr., <u>72</u>, 89628^t (1970).
- 64. Filler, R., Beaucaire, V.D. and Kang, H.H., J. Org. Chem., 40, 935 (1975).
- 85. Corvaisier, A., Bull. Soc. Chim. France, 528 (1962).
- 86. Tsukerman, S.V., Izvekov, V.P. and Lavrushin, V.F., Khim. Geterotsikl. Soedin, Akad. Nauk. Latv. SSR, 387 (1966); Chem. Abstr., 65, 12159^a (1966).
- 87. Dhar, D.N. and Singh, R.K., Zh. Obshch. Khim., <u>40</u>, 1156 (1970).
- 88. Venturella, P., Bellino, A. and Piozzi, F. Farmeo, Ed. Sci., <u>26</u>, 591 (1971); Chem. Abstr., <u>75</u>, 88432^z (1971).
- 89. Stepanova, G.P., Sakharova, N.A. and Stepanov, B.I., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., 14, 83 (1971); Chem. Abstr., 75, 35593^W (1971).
- 90. Belyaev, V.F., Grushevich, V.I. and Abrazhevich, A.I., Zh. Organ. Khim., 7, 610 (1971); Chem. Abstr., 75, 56177 (1971).
- 91. Deutsch. D.H. and Garcia, E.N., U.S. Patent 2,754,299 (1956); Chem. Abstr., <u>51</u>, 4437^h (1957).
- 92. Buu-Hoi, N.P., Xuong, N.D. and Trieu, T.C., Bull. Soc.
 Chim. France, 584 (1961); Chem. Abstr., <u>56</u>, 5907 (1962).
- 93. Ariyan, Z.S. and Suschitzky, H., J. Chem. Soc., 2242 (1961).

- 94. Velarde, E., Bol. Soc. Quim. Peru, <u>36</u>, 127 (1970); Chem. Abstr., <u>75</u>, 19808^q (1971).
- 95. Jurasck, A., Knoppova, V., Dandcrova, M., Kovac, J. and Reinprocht, L., Tetrahedron, 34, 1833 (1978).
- 96. Churkin, Y.D. and Savin, V.I., Khim. Geterotsikl. Socdin., Sb. No. 3, (1971) (Serusoder Zhashchie Geterotsikly), 60; Chcm. Abstr., 77, 88189^S (1972).
- 97. Hanson, G.A., Bull. Soc. Chim. Bclges, <u>67</u>, 712 (1958); Chem. Abstr., <u>53</u>, 17995^c (1959).
- 98. Devitt, P.F., Timoney, A. and Vickars, M.A., J. Org. Chem., 26, 4941 (1961).
- 99. Bolyacv, V.F. and Abrazhevich, A.I., Khim. Getcrotsikl. Socdin., 228 (1967); Chem. Abstr., 67, 73466² (1967).
- 100. Bolyacv, V.F. and Abrazhevich, A.I., Khim. Geterotsikl. Soedin., 827 (1967); Chem. Abstr., <u>68</u>, 114331^t (1968).
- 101. Real, L., Jone, M., Hilda, W. and George, M., Can. J. Chem., 46, 1952 (1968).
- Verkhovod, V.M., Roberman, A.I., Ostrovskaya, B.I., Verkhovod, N.N. and Lavrushin, V.F., Vestn. Kharkov un-ta, 113 (1974) (115 Khimya Vyp. 5); from Ref. Zh., Khim. 1975; Abstr., No. 1Zh249; Chem. Abstr., 83, 147361 (1975).
- 103. Fisera, L., Kovac, J. and Hrabovsky, J., Pr. Chem. Fak.

 SVST 1975-76 (Pub. 1978); Chem. Abstr., 90, 137601² (1979).
- Tsukerman, S.V., Orlov, V.D., Izvekov, V.P., Lavrushin, V.F. and Yur'ev, Y.K., Khim. Geterotsikl. Soedin., Λkad. Nauk Latv. SSR (1), 34 (1966); Chem. Abstr., 65, 674^a (1966).

- 105. Akaboshi, S. and Kutsuma, T., Yakugaku Zasshi, <u>88</u>, 1011 (1968); Chem. Abstr., <u>70</u>, 11524 (1969).
- 106. Tsukerman, S.V., Nikitchenko, V.M., Bugai, A.I. and Lavrushin, V.F., Khim. Str., Svoistva Reaktivnost Org. Soedin., <u>53</u> (1969); Chem. Abstr., <u>73</u>, 45276^t (1970).
- 107. Samula, K. and Cichy, B., Pol. J. Chem., <u>53</u>, 719 (1979); Chem. Abstr., 91, 157561^k (1979).
- 108. Matsumura, K., Ito, M. and Lee, S.T., J. Org. Chem., <u>25</u>, 854 (1960).
- 109. Akaboshi, S. and Kutsuma, T., Yakugaku Zasshi, <u>88</u>, 1016 (1968); Chem. Abstr., 70, 11525^W (1969).
- 110. Funke, A. and Delavigne, R., Bull. Soc. Chim. France, 1974 (1959).
- 111. Krasnaya, Z.A., Stytsenko, T.S., Prokofév, E.P. and Eucherov, V.F., Khim. Geterotsikl. Soedin., 5, 668 (1973); Chem. Abstr., 79, 78541° (1973).
- 112. Mikhaleva, M.A., Gulevich, V.V., Naumenko, I.I., Mamaev, V.P., Khim. Geterotsikl. Soedin., (5), 678 (1979); Chem. Abstr., 91, 91592ⁿ (1979).
- 113. Mal'tseva, S.P. and Stepanov, B.I., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., <u>16</u>, 1128 (1973); Chem. Abstr., <u>79</u>, 105130^b (1973).
- 114. Kucherenko, A.P., Potashnikova, S.G., Radkova, S.S., Baranov, S.N., Sheinkman, A.K., Volbushko, N.V., Khim. Geterotsikl. Soedin., (9), 1257 (1974); Chem. Abstr., 82, 72761^q (1975).

- 115. Toma, S. and Perjessy, A., Chem. Zvesti, <u>23</u>, 343 (1969); Chem. Abstr., <u>72</u>, 16942^f (1970).
- 116. Marchenko, I.G., Turov, A.V., Khilya, V.P., Dopov. Akad.

 Nauk Ukr. RSR. Ser. B. Geol. Khim., Biol. Nauk (1), 43

 (1979); Chem. Abstr., 90, 152350^d (1979).
- 117. Meyer, A., Debard, R., C. R. Acad. Sci., Paris, Ser. C, 264, 1775 (1967); Chem. Abstr., 67, 64503^g (1967).
- 118. Reichel, L. and Doering, H.W., Justus Liebigs Ann. Chem., <u>745</u>, 71 (1971).
- 119. Shah, N.M., J. Univ. Bombay, <u>11</u>, 109 (1942); Chem. Abstr., <u>37</u>, 2000⁷ (1943).
- 120. Yamada, S., Ono, F., Katagiri, T. and Tanaka, J., Bull. Chem. Soc. Japan, <u>48</u>, 2391 (1975).
- 121. Giri, S. and Singh, V.K., Indian J. Chem., 14B, 135 (1976).
- 122. Polyakov, V.K., Voronkin, V.M. and Tsukerman, S.V., Ukr. Khim. Zh., <u>42</u>, 388 (1976); Chem. Abstr., <u>85</u>, 21028^k (1976).
- 123. Ansari, M.A., Mathur, K.B. and Ahluwalia, V.K., Indian J. Chem., 16B, 702 (1978).
- 124. Malik, S.B., Sharma, P. and Seshadri, T.R., Indian J. Chem., 15B, 519 (1977).

PART - II

CHAPTER - 4.1

REACTION OF CHALCONES WITH REDUCING AGENTS

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Catalytic Hydrogenation

Reduction of Olefinic Group 1-11:

Chalcone on catalytic hydrogenation 1-4,10 with Raney nickel, in ethanol, yields benzylacetophenone. The latter compound has been secured in high yield (96%) by employing dichloroethane in place of ethanol as a solvent. High pressure hydrogenation (50-120 atmospheres) of chalcone, in the presence of a non-pyrophoric Raney nickel catalyst (composition: copper, 58-60% and aluminium, 40-42%) is reported to yield dihydrochalcone (75%).

Chalcones have been reduced by hydrogen and platinum to hydrochalcones, 7 which in turn can be reduced to hydrochalcols.

ortho-Hydroxychalcone⁸ is reduced completely to the corresponding dihydrochalcone, in ether, in the presence of platinum black, by a current of hydrogen. The preparation of several dihydrochalcones is described in literature. 55-66

With platinum oxide catalyst in ethanol (alkaline) the hydrogenation of chalcone stops with the absorption of one molecule of hydrogen and the exclusive formation of saturated ketone. A study is reported in respect of controlling catalytic hydrogenation (catalyst: platinum oxide) of chalcone under the influence of added ferric chloride, different solvents and temperature. Thus the saturation of the ethylenic bond occurs very smoothly either in cold benzene, toluene or boiling acetic acid.

 $\mathbb{P}d_3B_2$ is reported 11 to be an efficient catalyst in the selective hydrogenation of olefinic double bond in chalcone. It has, therefore, been employed 11 as a catalyst in the quantitative microhydrogenation of such types of compounds.

Reduction of Carbonyl Group:

p'-Mcthylchalcone is reduced by hydrogen to the corresponding unsaturated secondary alcohol, 12 using platinum black and large excess of ferric chloride.

Selective reduction of the carbonyl group in chalcone has likewise been achieved 13 by using optimum amount of palladium catalyst (promoters: ferrous sulphate-zine acetate) at ordinary atmospheric pressure and room temperature. Hydrogenation of chalcone, at atmospheric pressure, with colloidal palladium or with palladium precipitated on animal charcoal, is reported 14 to reduce smoothly the carbonyl group.

Reduction of Olefinic and Carbonyl Groups:

1,3-Diphenylpropanol⁵ has been secured by the catalytic hydrogenation of ethanolic solution of chalcone with Raneynickel. According to a report,⁴ the same transformation has been accomplished, in 45 minutes, by incorporating traces of alkali in the reaction medium.

Saturation of Olefinic Bond and Reduction of Carbonyl to Methylenc Group:

Catalytic reduction of chalcone by hydrogen in presence of nickel (reduced at 250°, and partially deactivated at 200°) yields 1,3-diphenylpropane. A quantitative yield of this compound is obtained by the catalytic hydrogenation of chalcone with platinum catalyst in cthanol, in presence of concentrated hydrochloric acid.

Reduction of Aromatic Rings and Enone Function:

Chalcone undergoes hydrogenation in presence of activated nickel catalyst, at elevated temperature to give dicyclohexyl-propane. Formation of a similar perhydro compound is reported in the case of p'-methylchalcone, involving the use of platinum black as a catalyst.

Complex Metal Hydride Reduction

Alkali Mctal Borohydrides:

Selective reduction of the double bond in chalcone occurs, when it is reacted in pyridine, with sodium borohydride. 15

Chalcone on treatment with potassium borohydride in water or methanol yields the corresponding carbinol. 16-18 This reaction has been extended for the preparation of several substituted allyl alcohols. 19,20 The selective reduction of

carbonyl group of chalcone has been achieved 17 by potassium borohydride and aluminium isopropoxide in isopropyl alcohol. The resulting compound often referred to as chalcol (1,3diphcnyl-2-en-1-ol)on treatment with alkali is reported 17 to undergo a rearrangement to yield the dihydrochalcone.

Sodium borohydride reduction of 2'-hydroxychalcone is reported²¹ to yield flav-5-ene, besides the expected unsaturated alcohol. 1,3-Diphenyl-1 (and 2-) propanols²² are obtainable in 85% yield by carrying out reduction of chalcone with sodium borohydride-boron trifluoride, followed by treatment with alkaline hydrogen peroxide. Using chalcone as the starting material the synthesis of flavanol (I) and its corresponding

been suggested for this reduction.

Lithium trimethoxyaluminohydride: LAH and Trimethoxyaluminium Hydride:

The reduction of chalcone with LAH can be controlled to yield either the unsaturated 24 or saturated alcohol. 25 This reaction has been exploited 26 in the synthesis of 4-cinnamylidene -2,5-cyclohexadien-1-ones. Thus 4'-hydroxychalcones have been reduced by LAH to the corresponding unsaturated alcohols, and the latter dehydrated to the aforesaid compounds. Chalcone is reported 27 to give the unsaturated alcohol as the major product, if LAH is replaced by the less aggressive reagent, Lithium trimethexyaluminofundade.

Lithium Aluminium Hydridc-Aluminium Chloride (LAH-AlCl3):

Treatment of chalcone with LAH-AlCl₃ yields the corresponding propence²⁸ and a dimer, 1,3,5-triphenyl-4-benzyl-1-pentenc²⁹ (44-65%).

The mechanism of the reaction has been postulated 28 as follows: With lithium aluminium hydride, chalcone undergoes transformation to the saturated alcohol. The latter compound loses a molecule of water, under the influence of the added Lewis acid, aluminium chloride, to yield the 1,3-diphenyl-1-propene.

In the hydrogenolysis of some chalcones (vide infra) two isomeric disubstituted propenes have been obtained. 28,30,31

In one instance the formation of an additional compound, viz., 1-(o-hydroxyphenyl)-3-phenyl-1-propanone has been reported. 30

It is interesting to note that 2-hydroxy-4'-methoxy-chalcones on hydrogenolysis yields three products, 28 viz., a saturated ketone (II), a secondary alcohol (III) and 4'-methoxy-clavan (IV). Apparently the reduction follows a different course 28:

In the reduction of 4- and 4'-methoxychalcones by lithium aluminium hydride-aluminium chloride (1:2) two dimers are reported³¹ to be formed, besides the isomeric 1,3-disubstituted propenes. The following structures have been postulated³¹ for these dimers:

The behaviour of \angle -(phenylsulphonyl) chalcone³² towards mixed reagents (LAH-AlCl₃) is rather interesting. It results in the saturation of the ethylenic double bond giving the corresponding hydrochalcone.³²

Organotin Hydride Reduction:

Diphenyl tin hydride³³⁻³⁵ brings about the reduction of chalcone to yield phenyl styryl carbinol (75%). The distinctive feature of the reaction is that the two hydrogen atoms undergo uncatalysed selective transfer from tin to the carbonyl group of chalcone to give directly the alcohol and no hydrolysis step is required.

1,3-Diphenyl-propan-1-one has been obtained from chalcone by its reaction with diphenyl tin hydride under appropriate conditions. The saturation of the double bond is the net result of two steps. 36 viz., hydrostannation (1,4-addition) and hydrogenolysis. With tributyl tin, 36 however, the reaction does not proceed beyond the hydrostannation stage.

Electrolytic Reduction:

Chalcone on electrolytic reduction is reported 37 to yield three products, viz., dibenzyldiacetophenone (35-40%), 1,3,4, 6-tetraphenyl-3,4-dihydroxyhexadiene (?, 25-30%) and the saturated ketone, $\emptyset CH_2CH_2CO\emptyset$ (10-15%). The yield of the latter could be raised to 70% by appropriate control of the

reaction conditions. The following mechanism has been proposed 38 for the electrolytic reduction of chalcone and its heterolytic analogue:

CH: CH. COR e+ H
Step (1)

$$\begin{cases}
R.CH: CH.C(OH). R' & Step(2) \\
Step & e+H \\
(3) & R.CH_2.CH_2.COR'
\end{cases}$$

$$Step & (3a)$$

$$Step & (V)$$

(b)
$$P = P! = P! = P!$$

(b)
$$R = R' = Phenyl$$

The ketone (V) can undergo further two one-electron-reduction to yield the corresponding saturated secondary alcohol, 38 thus:

$$R-CH_2-CH_2-CCH_$$

Meerwein-Ponndorf-Verley Reduction:

Allyl alcohols have been obtained (in 40-70% yield) by the Meerwein-Ponndorf-Verley reduction 39 of chalcones.

A modified method for the Meerwein-Ponndorf-Verley reduction of chalcone, involving the use of aluminium isoproposide and isopropyl alcohol, has been reported. 40 The removal of acetone from the reaction mixture is unnecessary. The product, 1,3-diphenyl-2-propen-1-ol is obtained in good yield (76%).

Reduction by Metals:

Lithium amalgam⁴¹ brings about the reduction of chalcone giving rise to a small amount of the corresponding alcohol (b.p. 168-71°). The reaction of chalcone with ammonium amalgam is not a clean one, and several products have been isolated.⁵⁴ The following are the products that are formed: 1,3,4,6-tetraphenyl-hexan -1,6-dione; 1,3,4,6-tetraphenyl-3,4-dihydroxy-1,5-hexadiene; 1,2,4,5-tetraphenyl cyclohexan-1,2-diol; 1,3-diphenyl-propyl alcohol and 1-amino-1, 3-diphenyl-3-propanol.

Benzyl acetophenone is obtained from chalcone when the latter is treated with sodium⁴² in alcohol.

1,3,4,6-Tetraphenylhexan -1,6-dione⁴² is produced when chalcone is reduced as in Clemmensen reaction or treated with zinc mercury in acetic acid.

2-Hydroxy-3,4-dimethoxy-3',4'-methylenedioxychalcone on reduction with zinc in ethyl alcohol-acetic acid gives amorphous 4-hydroxy-7,8,4'-trimethoxyflavan. 38 Under the same reaction conditions butein yields the corresponding flavan or the pinacol 43

Chalcone, 44 on the other hand yields dibenzyldiacetophenone (m.p. 196°) and an isomer (m.p. 269°). Chalcone is reported to undergo reduction by vanadous and chromous salts with the formation of bimolecular products. 45 For example:

 $2\&cH = cH \cos \& + 5A_{++} + 5H_{+} \longrightarrow (\&cH - cH^{5} - cO - \&)^{5} + 5A_{+++}$

Willgerodt-Kindler Reaction 46:

Dihydrochalcone (40%) has been obtained by heating chalcone with sulphur at 115° in the presence of quinoline. Besides the dihydrochalcone; 1,3-diphenylprop-1-ene is also formed, when the above reaction is carried out at a higher temperature (145°). Reduction of olefinic bond in the Willgerodt-Kindler reaction has also been observed in the case of 4-chlorochalcone. However, according to a recent report, 67 cinnamic acld is produced when chalcone is heated in morpholine in presence of sulphur.

Reduction by 'Hantzch Ester':

The activated double bond of chalcone is selectively reduced, ⁴⁷ by 'Hantzch ester' (diethyl-1,4-dihydro-2,6-dimethylpyridine-3,5-dicarboxylate) to yield benzylacetophenone and illustrates a case of homogeneous hydrogen transfer reaction.

Reduction by Pyridine-Borane Reagent:

The selective reduction of the carbonyl group in chalcone has been accomplished with pyridine-borane reagent. 48

Reduction by Terpenes 49:

Hydrogenation of the olefinic double bond in chalcone can be effected by the use of terpenes especially phellandrene and limonene, as hydrogen donors. Thus benzyl acetophenone is produced when chalcone and limonene are refluxed in xylene. The same product results when p-chlorochalcone is subjected to the same treatment, using phellandrene as hydrogen donor. Apparently reductive dehalogenation occurs in the latter reaction.

Miscellancous Reduction:

The reduction and alklylation in the \ll - and β -positions of chalcone in liquid ammonia have been reported. 50,51

Chalcone has been converted into its corresponding saturated aminc (53%) by reductive amination. The reaction can be conducted by introducing hydrogen gas into an aqueous ethanolic ammonia solution containing chalcone and cyanocobalt complex.

References

- 1. Bar, D. and Debruyne, Mme. E., Ann. Pharm. Franc., <u>16</u>, 235 (1958); Chem. Abstr., <u>53</u>, 4183^h (1959).
- 2. Linke, H.A.B. and Eveleigh, D.E., Z. Naturforsch., 30B, 606 (1975).
- 3. Linke, H.A.B. and Eveleigh, D.E., Z. Naturforsch., 30B, 940 (1975).

- 4. Tucker, S.H., J. Chem. Education, 27, 489 (1950).
- 5. Cornubert, R. and Eggert, H.G., Bull. Soc. Chim. France, 522 (1954).
- 6. Ponomarcv, A.A., Pinkel'shtein, A.V. and Kuz'mina, Z.M., Zh. Obshch. Khim., 30, 564 (1960).
- 7. Pfeiffer, P., Kalckbrenner, E., Kunze, W. and Levin, K., J. Prakt. Chem., 119, 109 (1928).
- 8. Bargellini, G. and Bini, L., Gazz. Chim. Ital., 41, II, 435.
- 9. Weidlich, H.A. and Delius, M.M., Chem. Ber., <u>74B</u>, 1195 (1941).
- 10. Weygand, C. and Meusel, W., Chem. Ber., 76B, 498 (1943).
- 11. Burlaka, V.P. and Diakur, L.N., Izv. Sib. Otd. Akad. Nauk SSSR Ser. Khim. Nauk (2), 128 (1967); Chem. Abstr., <u>68</u>, 53715^x (1968).
- 12. Weygand, C. and Werner, A., Chem. Ber., 71B, 2469 (1938).
- 13. Csuros, Z., Zech, K. and Geczy, I., Hung. Acta Chim., 1, 1 (1946); Chem. Abstr., 41, 109ⁱ, 110^a (1947).
- 14. Csuros, Z., Muegyetemi Közlemények, 110 (1947); Chem. Abstr., 42, 3727^b (1948).
- 15. Iqbal, K. and Jackson, W.R., J. Chem. Soc. C, 616 (1968).
- 16. Huls, R. and Simon, Y., Bull. Soc. Roy. Sci. Liege, <u>25</u>, 89 (1956); Chem. Abstr., <u>50</u>, 16664^h (1956).
- 17. Davey, W. and Hearnes, J.A., J. Chem. Soc., 4978 (1964).
- 18. Flammang, M. and Wermuth, C.G., Bull. Soc. Chim. France, (2), Pt. (2), 674 (1973).

- Lavrushin, V.F., Kutsenko, L.M., Grin, L.M. and Litvin,
 I.Y., Ukr. Khim. Zh., 34, 413 (1968); Chem. Abstr., 69,
 76794^g (1968).
- 20. Grin, L.M., Kutschko, L.M. and Lavrushin, V.F., Vestn.

 Khar'kov Univ., 46, 81 (1970); Chem. Abstr., 75, 140426^S

 (1971).
- 21. Cardillo, G., Cricchio, R., Merlini, L. and Nasini, G., Gazz. Chim. Ital., 99, 612 (1969).
- 22. Thankar, G.P. and Subbarao, B.C., J. Sci. Ind. Res. (India), 21B, 583 (1962).
- 23. Das, S.C., Technology (Sindri, India), <u>11</u>, 91 (1974); Chem. Abstr., 82, 72350⁶ (1975).
- 24. Hochstein, F.A., J. Am. Chem. Soc., 71, 305 (1949).
- 25. Brown, W.G., Organic Reaction, 6, 482 (1954).
- 26. Kurosawa, K., Hashiba, A. and Takahashi, H., Bull. Chem. Soc. Japan, 51, 3612 (1978).
- 27. Durand, J. and Huet, J., Bull. Soc. Chim. France, (7-8 Pt-2), 428 (1978).
- 28. Bokadia, M.M., Brown, B.R., Cobern, D., Roberts, A. and Somerfield, G.A., J. Chem. Soc., 1658 (1962).
- 29. Hase, T., Acta Chem. Scand., 23, 2409 (1969).
- 30. Hase, T., Acta Chem. Scand., 22, 2845 (1968).
- 31. Hase, T., Acta Chem. Scand., 23, 2403 (1969).
- 32. Balaiah, V. and Natarajan, C., Indian J. Chem., 9, 1025 (1971).

- 33. Kuivila, H.G. and Bcumel, O.F. (Jr.), J. Am. Chem. Soc., 80, 3798 (1958).
- 34. Kuivila, H.G. and Beumel, O.F. (Jr.), J. Am. Chem. Soc., 83, 1246 (1961).
- 35. Kuivila, H.G. and Beumel, O.F. (Jr.), U.S. Patent, 2,997,485 (1958); Chem. Abstr., <u>57</u>, 866 (1962).
- 36. Lousink, A.J. and Noltes, J.G., Tetrahedron Letters, 2221 (1966).
- 37. Shima, G., Mcm. Coll. Sci. Kyoto Imp. Univ., <u>12Λ</u>, 327 (1929); Chcm. Abstr., <u>24</u>, 2118⁵ (1930).
- 38. Ariyan, Z.S., Mooncy, B. and Stonehill, H.I., J. Chem. Soc., 2239 (1962).
- 39. Lavrushin, V.F., Kutschko, L.M. and Grin, L.M., Zh. Organ. Khim., 3, 72 (1967); Chem. Abstr., 66, 94751h (1967).
- 40. Truett, W.L. and Moulton, W.N., J. Am. Chem. Soc., <u>73</u>, 5913 (1951).
- 41. Kamctani, T. and Nomura, Y., J. Pharm. Soc. Japan, <u>74</u>, 1037 (1954); Chcm. Abstr., <u>49</u>, 11594^b (1955).
- 42. Frederick, J., Dippy, J. and Lewis, R.L., Rec. Trav. Chim., 56, 1000 (1937); Chem. Abstr., 32, 521^{5,7} (1938).
- 43. Russell, A., J. Chem. Soc., 218 (1934).
- 44. Finch, L.R. and White, D.E., J. Chem. Soc., 3367 (1950).
- 45. Conant, J.B. and Cutter, H.B., J. Am. Chem. Soc., <u>48</u>, 1016 (1926).
- 46. Compagnini, A. and Purrello, K., Gazz. Chim. Ital., <u>95</u>, 686 (1965).

- 47. Braude, J.A., Hannah, J. and Linstead, R., J. Chem. Soc., 3257 (1960).
- 48. Barner, R.P., Graham, J.H. and Taylor, M.D., J. Org. Chem., 23, 1561 (1958).
- 49. Kindler, K. and Luchrs, K., Ann. Chem., <u>685</u>, 36 (1965); Chem. Abstr., <u>63</u>, 8409^h (1965).
- 50. Gautier, J.A., Miocque, M. and Duclos, J.P., Bull. Soc. Chim. France (12), 4348 (1969); Chem. Abstr., <u>72</u>, 89494^W (1970).
- 51. Gautier, J.A., Miocque, M. and Duelos, J.P., Bull. Soc. Chim. France (12), 4356 (1969); Chem. Abstr., <u>72</u>, 100226^h (1970).
- 52. Murakami, M., Suzuki, K., Fujishige, M. and Kang, J.W., Nippon Kagaku Zasshi, <u>85</u>, 235 (1964); Chem. Abstr., <u>61</u>, 13408^b (1964).
- 53. Prezouls, J., Compt. Rend., <u>155</u>, 42.
- 54. Takagi, S. and Sakaguti, T., J. Pharm. Soc. Japan, <u>58</u>, 797 (1938); Chem. Abstr., <u>33</u>, 2508⁸ (1939).
- 55. Bargellini, G. and Finkelstein, M., Gazz. Chim. Ital., 42, II, 417; Chem. Abstr., 7, 1713⁷ (1913).
- 56. Bargellini, G. and Martegiani, E., Gazz. Chim. Ital., <u>42</u>, II,427; Chem. Abstr., <u>7</u>, 1713⁹ (1913).
- 57. Bargellini, G. and Monti, L., Gazz. Chim. Ital., <u>44</u>, II, 25 (1914); Chem. Abstr., <u>9</u>, 447 (1915).
- 58. Bargellini, G., Gazz. Chim. Ital., 44, 421, Atti. Accad.

- Lincei, 23, II, 135 (1914); Chem. Abstr., 9, 1042 (1915).
- 59. Massicot, J., Compt. Rend., 240, 94 (1955).
- 60. Bhat, A.R., Joshi, V. and Merchant, J.R., Current Sci., 44, 345 (1975).
- 61. Shinoda, J., Sato, S. and Kawagoe, M., J. Pharm. Soc. Japan, 49, 797 (1929).
- 62. Klinke, P. and Gibian, H., Chem. Ber., 94, 26 (1961).
- 63. Maria Ada Jorio, Ann. Chim. (Rome), <u>49</u>, 1929 (1959); Chem. Abstr., <u>54</u>, 14235° (1960).
- 64. Bognar, R., Tokes, A.L. and Frenzel, H., Acta Chim.

 (Budapest), 61, 79 (1969); Chem. Abstr., 71, 113217k (1969).
- 65. Horowitz, R.M. and Gentili, B., U.S. Patent 3,429,873 (1969); Chem. Abstr., 70, 87315^y (1969).
- 66. Laboratoires Coupin (S.A.), French Patent 1,221,869 (1960); Chem. Abstr., <u>56</u>, P 10046ⁱ (1962).
- 67.65. Sathe, S.W. and Ghiya, B.J., Current Sci., 46, 446 (1977).

CHAPTER - 4.2

REACTION OF CHALCONES WITH OXIDIZING AGENTS

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	그 이 그리는 사람이 하는 사람들이 얼마나 살아 하다는 사람들이 가지 그리고 하는데 되었다.	11

Thallic Salts:

A simple and convenient method for the preparation of symmetrical as well as unsymmetrical benzils consists in the oxidation of appropriate chalcones with thallic nitrate (TN):

$$\begin{array}{c} R_2 & TN & R' \\ \hline \\ \text{in aq acid} \\ \hline \\ \text{glyme} \end{array}$$

The yield of benzils are in the range of 45-70%. The reaction, however, fails when substituents prone to oxidation (viz. hydroxyl and amino groups) are present, or when both the aromatic rings carry electron withdrawing functions.

The mechanism involved in the thallic nitrate (TM) exidation of chalcone is shown below:

Arch=ch co ar'
$$\xrightarrow{TN}$$
 Ar \xrightarrow{CH} Coar' \xrightarrow{H}

Arch=ch co ar' \xrightarrow{TN} Arch= \xrightarrow{CH} Coar' \xrightarrow{H}

Arch=ch-coar' \xrightarrow{H} Arch= \xrightarrow{CH} \xrightarrow{CH}

nucleophilic displacement of thallium, leads to the formation of benzoin (VI). (c) Finally, the oxidation of VI gives the benzil (VIII).

If the oxidative rearrangement of chalcone (IX) brought about by thallic salt, is carried out in the presence of methanol, ketoaceta (X) results:

The reaction (X)

intermediate organothallium derivative, followed by its rearrangement. 7,9,35,36

This reaction has been exploited for the synthesis of isoflavones. 7,9,35,36

For example, (X) after treatment with methanolic hydrochloric acid, yielded smoothly 3',7-diethoxy-2',4'-dimethoxyisoflavone. 7

2'-Hydroxychalcones have also been shown 10 to undergo oxidative rearrangement (vide supra) with thallic salts to yield finally the corresponding isoflavones. 10 The syntheses of

several naturally occurring isoflavones $^{11-13}$ and related compounds are based on the aforesaid reaction.

The kinetics of thallic acetate oxidation of chalcone has been studied. 14

Lead Tetraacetate:

The β -hydroxy-chalcones on oxidation with lead tetra-acetate sive the corresponding benzils together with aromatic acids. In the case of 4,4'-dimethoxy- β -hydroxy-chalcone, however, the formation of three products (XI-XIII) reported. 15

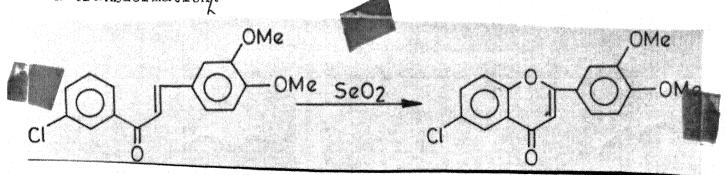
Lead tetraacetate oxidation of 2'-hydroxychalcones, 16 however, yield <u>cis-</u> and <u>trans-aurones</u>, substituted cinnamic and benzoic acids. Five products (XIV-XVIII) are obtained when 2'-benzyloxy-4,4'-dimethoxychalcone is oxidized by the above oxidant.

CH₂
$$\phi$$
OAC
OME
MEO
OAC
OME
MEO
OAC
OME
MEO
OAC
OH
OAC
OH
OCH₂ ϕ
OCH₃
OCH₃
OCH₃
(XVII)

(XVIII)

Selenium Dioxides

Chalcones are oxidized smoothly with selenium dioxide to the flavones. 17-19 The following serves as an example for such a transformation,



Manganic Acetate:

Fairly good yields of aurones 16,20 are obtainable from 2'-hydroxychalcones by oxidation with manganic acetate in acetic acid. The mechanism of the reaction is outlined as follows 20:

Chromic Acid:

Epoxidation takes place when chalcone and its derivatives are treated with chromic acid. The kinetics of this reaction has been studied. The reaction is reported to involve the electrophilic attack by chromic acid at the olefinic centre of chalcone molecule, resulting in the formation of an epoxide.

Osmium Tetroxide²²:

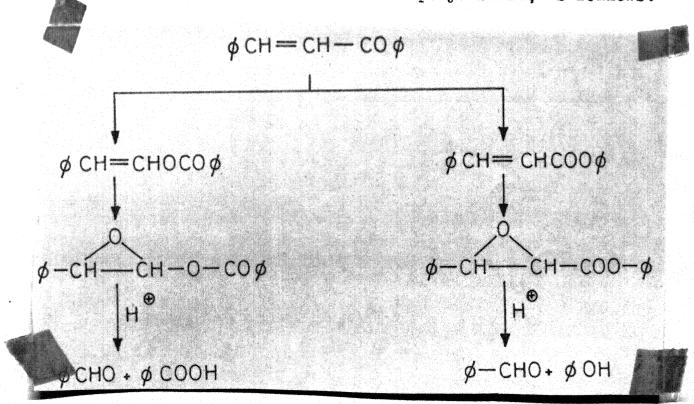
Chalcone and osmium tetroxide react in ether solution to give a monoester, $C_{15}H_{12}O_5Os$ in 64% yield.

Trifluoroperoxyacetic Acid:

Oxidative cyclisation of chalcones to flavylium salts have been achieved by the use of trifluoroperoxyacetic acid²³ in methylene chloride. The reagent serves as an electrophilic hydroxylating²⁴ system. A plausible mechanism²³ for this reaction is given:

Perbenzoic Acid:

The reaction of perbenzoic acid with chalcone has been studied. 25 The oxidation of chalcone is considered 26 to proceed through the intermediate formation of epoxy-esters, as follows:



Potassium Persulphate:

Potassium persulphate, under appropriate experimental conditions is reported 27 to cause the nuclear oxidation of hydroxy-chalcones, as is illustrated by 2'-hydroxy-4'-methoxychalcone (vide infra):

Some <u>trans</u> 1-aryl-2-aroyloxy ethylenes (XIX) have been secured 28 by the persulphate oxidation of chalcone and naphthalene analogue of chalcone:

Arc-ch=ch-Ar'
$$\frac{K_2S_2O_8-H_2SO_4-HOAc}{O}$$
 Ar-c-o-ch=ch-Ar' O (XIX)

Ar=Ph;
$$2-C_{10}H_{7}$$
;
Ar'=Ph; $4-MC_{6}H_{4}$; $2-C_{10}H_{7}$

tert-Butyl Hydroperoxide:

Chalcone is reported to undergo epoxidation when treated with <u>tert</u>-butyl hydroperoxide²⁹ in the presence of triton-B. With this reagent it is possible to carry out the reaction in a completely homogeneous non-polar medium. The mechanism²⁹ involved in epoxidation is depicted below:

The equilibrium concentration of the carbanion is sufficiently large to enable step (iii) to compete with the protonation step (ii). Since the elimination step is irreversible, therefore, the reaction is driven in the direction of epoxide formation.

Epoxidation of chalcones has also been achieved by using monoperphthalic acid, 30 as well as by hydrogen peroxide in alkaline medium 31,32 (see under AFO reaction). The latter method has been extended to the preparation of heterocyclic epoxychalcones. 32

<u>Autoxidation</u>:

Chalcone is autoxidized³³ very slowly, in presence of potassium <u>tert</u>. butoxide-<u>tert</u>. butyl alcohol, to two equivalents of benzoic acid (75%).

Potassium Ferricyanide:

2',4-Dihydroxy-4',6'-dimethoxychalcone (XX) is reported 34 to undergo oxidative phenol coupling at the $m{\beta}$ -position to yield

Amine N-oxides:

Flavones have been prepared³⁷ from 2'-hydroxychalcones by their oxidation with amine N-oxides, viz., pyridine oxide and triethylamine oxide, in the presence of a catalyst.

References

- 1. McKillop. A., Swann, B.P. and Taylor, E.C., Tetrahedron Letters, 5281 (1970).
- McKillop, A., Swann, B.P., Ford, M.E. and Taylor, E.C.,
 J. Am. Chem. Soc., 95, 3641 (1973).
- 3. Ollis, W.D., Ormand, K.L. and Sutherland, I.O., J. Chem. Soc., C, 119 (1970).

- 4. Gottsegen, A., Antus, S., Farkas, L., Kardos-Balogh, Z. and Nagradi, M., Flavonoids Bioflavonoids Proc. Hung. Bioflavonoid Symp., 5th, 1977, pp. 181-5. Edited by Farkas, T., Gubor, M. and Kallay, F., Elsevier, Amsterdam, Netherlands.
- 5. Taylor, E.C., Conley, R.A., Johnson, D.K. and McKillop, A., J. Org. Chem., 42, 4167 (1977).
- 6. Antur, S., Boross, F., Farkas, L. and Nogradi, M., Flavonoid Bioflavonoids Proc. Hung. Bioflavonoid Symp., 5th, 1977, pp. 171-80. Edited by Farkas, T., Fubor, M. and Kallay, F., Elsevier, Amsterdam, Netherlands.
- 7. Ollis, W.D., Ormand, K.L., Redman, B.T., Roberts, R.J. and Sutherland, I.O., J. Chem. Soc., C, 125 (1970).
- 8. Ollis, W.D., Ormand, K.L. and Sutherland, I.O., Chem. Commun., 1237 (1968).
- Levai, A. and Balbgh, L., Pharmazie, 30, 747 (1975);
 Chem. Abstr., 84, 59070^k (1973).
- 10. Farkas, L., Gottsegen, A., Nogradi, M. and Antus, S., Chem. Commun., 825 (1972).
- 11. Farkas, L., Gottsegen, A., Nogradi, M. and Antus, S., J. Chem. Soc., Perkin Trans., 1, 305 (1974).
- 12. Farkas, L., Antus, S. and Nogradi, M., Acta Chim. Acad.
 Sci. Hung., 82, 225 (1974); Chem. Abstr., 81, 120319 (1974).
- 13. Antus, S., Farkas, L., Kardos-Balogh, Z. and Nogradi, M., Chem. Ber., 108, 3883 (1973).

- 14. Khandual, N.C., Satpathy, K.K. and Nayak, P.L., Proc. Indian Acad. Sci., <u>76A</u>, 129 (1972).
- 15. Kurosawa, K. and Moriyama, A., Bull. Chem. Soc. Japan, <u>47</u>, 2717 (1974).
- 16. Kurosawa, K. and Higuchi, J., Bull. Chem. Soc. Japan, <u>45</u>, 1132 (1972).
- 17. Mahal, H.S., Rai, H.S. and Venkataraman, K., J. Chem. Soc., 866 (1935.
- 18. Mahal, H.S. and Venkataraman, K., J. Chem. Soc., 569 (1936).
- 19. Chakravarti, D. and Dutta, J., J. Indian Chem. Soc., <u>16</u>, 639 (1939).
- 20. Kurosawa, K., Bull. Chem. Soc. Japan, 42, 1456 (1969).
- 21. Ithandual, N.C., Satpathy, K.K. and Nayak, P.L., J. Chem. Soc. Perkin Trans., 2, 328 (1974).
- 22. Criegee, R., Marchand, B. and Wannowius, H., Ann., <u>550</u>, 99 (1942).
- 23. Brown, B.R., Davidson, A.J. and Normon, R.O.C., Chem. and Ind. (London), 1237 (1962).
- 24. Chambers, R.D., Goggin, P. and Musgrave, W.K.R., J. Chem. Soc., 1804 (1959).
- 25. Young, W.G., Cristol, S.J., Andrews, L.J. and Lindenbaum, S.L., J. Am. Chem. Soc., <u>66</u>, 855 (1944).
- 26. Yokoyama, T. and Nohra, F., Bull. Chem. Soc. Japan, 38, 1498 (1965).
- 27. Rajagopalan, S. and Seshadri, T.R., Proc. Indian Acad. Sci., <u>27A</u>, 85 (1948).

- 28. Dhar, D.N. and Munjal, R.C., Synthesis, 9, 542 (1973).
- 29. Yang, N.C. and Finnegan, R.A., J. Am. Chem. Soc., <u>80</u>, 5845 (1958).
- 30. Verma, B.L. and Bokadia, M.M., J. Indian Chem. Soc., <u>42</u>, 399 (1965).
- 51. Belyaev, V.M. and Yatsevich, N.M., Khim. Geterotsikl. Soedin., <u>4</u>, 582 (1968); Chem. Abstr., <u>70</u>, 37565 (1969).
- 32. Korotkov, S.O., Orlov, V.D. and Lavrushin, V.F., Vestn. Kharkov Univ., <u>84</u>, 72 (1972); Chem. Abstr., <u>78</u>, 147695² (1973).
- 33. Doering, W.V.E. and Haines, R.M., J. Am. Chem. Soc., <u>76</u>, 482 (1954).
- 34. Volsteedt, F. du R., Ferreira, D. and Roux, D.G., Chem. Commun., 217 (1975).
- 35. Farkas, L. and Wolfner, A., Acta Chim. Acad. Sci. Hung., 88(2), 173 (1976).
- 36. Jain, A.C., Khazanchi, R. and Gupta, R.C., Bioorg. Chem.,
 7, 493 (1978).
- 57. Haginiwa, J., Higuchi, Y., Kawashima, T. and Shinokawa, H., Yakugoku Zasshi, 96, 195 (1975); Chem. Abstr., 85, 123724^b (1976).

CHAPTER - 4.3

REACTION OF CHALCONES WITH KETONES

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Isopropyl and Isobutyl Ketones:

Several diketones, as <u>erythro-threo</u> mixtures, have been prepared by the reaction of chalcones with enclates derived from isopropyl and isobutyl ketones.

Acetophenones:

Chalcone is reported 2 to undergo 1,2- or 1,4-addition with the ketone enolates, depending upon the conditions of experiment. Chalcone and MeO-CH, COPh cyclised with ammonium acetate-acetic acid to yield 2,4,6-triphenyl pyridine3. Chalcone-LAH complex in ether solution is reported⁴ to react with acetophenone to yield 2,3,5-triphenylpentan-2,5-diol.

Benzophenone:

The benzophenone-sensitized irradiation of chalcone

Disodiobenzophenone salt is reported to react with chalcone to form, after acidification, the keto alcohol, viz., $\beta, \gamma, \gamma \text{-triphenyl-}\gamma\text{-hydroxybutyrophenone, in 47\% yield.}$

Na
$$\phi_2$$
-C-ONa ϕ_2 -CH-CH=C(ONa) ϕ_2 -CONa ϕ_2 -CH-CH=C(ONa) ϕ_2 -CONa ϕ_2 -CONa ϕ_2 -CONa

Phenyl Benzyl Ketone 7:

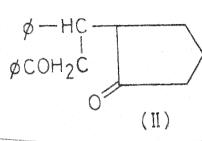
A quantitative yield of the Michael adduct is obtained when 4'-methylchalcone is treated with phenylbenzyl ketone under alkaline conditions. However, a pyrylium salt is produced, if triphenylmethyl perchlorate is used in the aforesaid reaction. Thus

$$\phi$$
-coch=ch ϕ + ϕ chco ϕ $\frac{\phi_3 c^{\circ} c_{10} c_{10}}{\phi}$ $\frac{\phi}{\phi}$ $\frac{\phi$

Cyclopentanone 9-12:

Under the influence of diethylamine or piperidine, chalcone reacts with cyclopentanone yielding a semicyclic-1,5-diketone, viz., \angle -benzoyl- β -phenyl cyclopentanonylethane (II)







3-Methylcyclohexanone 11,12:

The 1,5-diketone, viz., \angle -benzoyl- β -phenyl (3-methyl cyclohexanonyl) ethane, in two stereoisomeric forms is obtained by the reaction of 3-methyl cyclohexanone with chalcone, under appropriate conditions. Michael reaction of chalcone with 2-methylcyclohexanone is also reported. 10

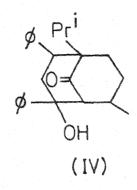
Tetraphenylcyclopentadienone:

2,3,4,5,6-Pentaphenylbenzophenone¹³ results from the reaction of chalcone and tetraphenylcyclopentadienone at an elevated temperature (~300°).

Menthone:

A bicyclic ketoalcohol 14 (III) or (IV) result by the interaction of chalcone and menthone in the presence of sodium ethoxide:

$$\phi$$
-CH=CH CO ϕ + ϕ EtONa





2,4 - Diphenyl -5 (or 1) - isopropyl -8 (or 6) methyl 9-keto-4-hydroxybicyclononane

Fenchone and Camphor:

Dibenzal triacetophenone 15 is formed when chalcone is reacted with alcoholic sodium hydroxide in the presence of fenchone or camphor.

Flavanones 16,17;

Chalcone and flavanone undergo addition reaction in the presence of a base, viz., sodium amide, sodium or caustic alkali, to yield 2-phenyl-2-phenacyl benzyl 2,3-dihydro-1,4-benzopyrone.

The presence of a 3',4'-methylenedioxy substituent in the chalcone component retards the aforesaid reaction, while a nitro group inhibits the same. 17 A mechanism for the aforesaid reaction has been suggested. 18

2-Substituted 5,6-benzochromanone:

Michael adducts are formed when chalcone is allowed to react with 2-substituted 5,6-benzochromanone. The following serve as an illustrative example:

$$\phi CH = CHCO \phi - CH_2CO \phi$$

$$CH_2CO \phi$$

$$CH_2CO \phi$$

R = OH

Acetylacetone:

Chalcone reacts with acetyl acetone 20 (at 120°) to yield cyclohexenone derivative (V). When the above reaction is conducted at room temperature, an addition product (VI) is obtained 20:

V (40-43%)

[R = R' = H ; R = H ; R' = OMe ; RR' = OCH20]

Dihydroresorcinol²¹:

2- [1-Phenyl-2-benzoyl ethyl] cyclohexane 2,6-dione (VII) has been secured
$$0 \\ + \phi COCH = CH \phi - \phi COCH_2 - CH - \phi COCH_2 -$$

in 58% yield by the reaction of dihydroresorcinol and chalcone.

5,5-Dimethylcyclohexandione:

Condensation of VIII with chalcone or pp'-dimethoxychalcone, in the presence of piperidine or sodium ethoxide gave IX²² in a good yield. Higher yields were obtained with sodium ethoxide catalyst.

2-Nitro-1,3-Indandione:

A good yield (74%) of 1,3-diphenyl-3 (2-nitro-1,3-indandion-2-yl)-1-propanone has been obtained 23 by the interaction of chalcone with 2-nitro-1,3-indandione in hexane.

Benzylidene bis (acetophenone):

The synthesis of pyrylium salt has been achieved 24 by the interaction of benzylidene bis (acetophenone) with chalcone in acetic acid medium, using boron trifluoride as the catalyst.

1,3,5-Triphenylpenten-1,5-dione:

The interaction of 1,3,5-triphenylpentan-1,5-dione and chalcone in presence of perchloric acid results in the formation of pyrylium salt. ²⁵ In this reaction chalcone is reported ²⁵ to act as a hydride ion acceptor.

References

- 1. Gorrichon-Guigon, L., Maroni-Barnaud, Y. and Maroni, P., Bull. Soc. Chim. France (11), 4187 (1972).
- 2. Bertrand, J., Gorrichon, L. and Maroni, P., Tetrahedron Letters, 4207 (1977).
- 3. Teuber, H.J., Bader, H.J. and Schuetz, G., Justus Liebigs Ann. Chem., 9(8), 1335 (1977).
- 4. Dornow, A. and Bartsch, W., Chem. Ber., 87, 633 (1954).

- 5. Abdel-Megeid, E.M.F., Bose, A.K., Elkaschef, A.F., Elsayed, A.S., Mokhtar, K.E. and Sharma, S.D., Indian J. Chem., 13, 482 (1975).
- 6. Hamrick, P.J. (Jr.) and Hauser, C.R., J. Am. Chem. Soc., 81, 493 (1959).
- 7. Sammour, A., Selim, M.I.B., Essawy, A. and Elkasaby, M., Egypt. J. Chem., <u>16</u>, 197 (1973); Chem. Abstr., <u>81</u>, 135630^y (1974).
- 8. Carretto, J., Sib, S. and Simalty, M., Bull. Soc. Chim. France (6), 2312 (1972).
- 9. Striegler, C., J. Prakt. Chem., <u>86</u>, 241.
- 10. Sammour, A., Raouf, A., Elksaby, M. and Ibrahim, M.A., Acta Chem. (Budapest) 78, 399 (1973); Chem. Abstr., 79, 146100^k (1973).
- 11. Georgi, R. and Volland, H., J. Prakt. Chem., <u>86</u>, 232.
- 12. Rosenberg, A., J. Prakt. Chem., <u>86</u>, 250.
- 13. Wolinski, J., Roczniki Chem., <u>26</u>, 168 (1952); Chem. Abstr., <u>49</u>, 6873^e (1955).
- 14. Stobbe, H. and Rosenberg, A., J. Prakt. Chem., 86, 226.
- 15. Georgi, R. and Schwyzer., A., J. Prakt. Chem., <u>86</u>, 273.
- 16. Kaplash, B.N., Shah, R.C. and Wheeler, T.S., Current Sci., 8, 512 (1939).
- 17. Kaplash, B.N., Shah, R.C. and Wheeler, T.S., J. Indian Chem. Soc., 19, 117 (1942).
- 18. Dhar, D.N., Agra Univ. J. Res. (Sci.) Part I, 10, 75 (1961);

- Sammour, A., Selim, M.I.B., Elkasaby, M. and Saied, F.,
 J. Prakt. Chem., 314, 941 (1972).
- 20. Sammour, A., Selim, M.I.B. and Hataba, A.M., Egypt. J. Chem., 15, 531 (1972); Chem. Abstr., 80, 82181 (1974).
- 21. Mikhailov, B.M., J. Gen. Chem. (USSR), 7, 2950 (1937).
- 22. Lelyukh, L.I., Korshunova, K.M. and Kharchenko, V.G., Izv.

 Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., 18, 1536 (1975);

 Chem. Abstr., 84, 30597^b (1976).
- 23. Zalukaevs, L.P. and Klykova, L.V., Zh. Obshch. Khim., 34, 3821 (1964).
- 24. Csuros, Z., Sallay, P. and Deak, G., Acta Chim. (Budapest), 79, 549 (1973); Chem. Abstr., 80, 59143^d (1974).
- 25. Van Allan, J.A. and Reynolds, G.A., J. Org. Chem., <u>33</u>, 1102 (1968).

CHAPTER - 4.4

REACTION OF CHALCONES WITH ESTERS

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	Ethyl Acetoacetate 91	ļ
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	Ethyl Cyanoacetate	3
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	Ethyl Thioglycolate	4
	Malonic Esters9	5
	Methyl Succinate 9	7
	Dimethyl Acetylene Dicarboxylate9	7
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Ethyl Acetate:

Chalcone undergoes a Michael type of reaction with ethyl acetate¹, in the presence of triphenyl methyl sodium to yield ethyl \ll -acetyl β -phenyl- γ -benzoyl butyrate (66%).

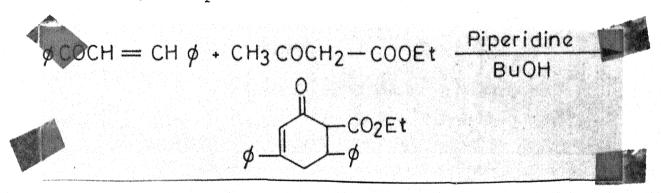
Ethyl Acetoacetate:

Chalcone reacts with ethyl acetoacetate to yield a variety of different compounds, viz., Michael adduct², pyrylium salt³ or cyclohexanone⁴ derivative, depending upon the experimental conditions employed. Thus, in the presence of boron trifluoride

etherate, the above reaction yields the pyrylium salt according to the reaction³:

$$CH_3COCH_2COOEt + \phi COCH = CH \phi$$

Here the chalcone, beside entering the reaction, also acts as a hydride ion acceptor and gets converted to dihydrochalcone. Chalcone⁴ and its derivatives⁵⁻⁷ undergoes condensation with ethyl acetoacetate to yield the corresponding cyclohexanone derivatives. Example^{4,8}:



Furan analogue of chalcone also reacts with ethyl acetoacetate in the above manner.

Ethyl Phenyl Acetate:

Chalcones-carrying substituents in ring B- have been reacted with ethyl phenyl acetate 10 to yield butyrates of the following type: R'-C6H4CH(CH2COPh)CHPhCO2Et. Under Michael

Ethyl Benzoylacetate:

Chalcones react with ethyl benzoyl acetate 12 to yield the Michael adduct, which on treatment with acid undergoes decarbethoxylation to furnish the diketone:

$$4-\text{MeO}-c_6H_4-c-cH=cHØ + c_6H_5cocH_2-c-oEt$$

HOAC-HC1
$$\rightarrow$$
 4-MeOC₆H₄COCH₂CHØCH₂COØ

$$CNCH_2 COOEt$$

$$Et_2NH^{(4)}$$

$$Cooet$$

$$NH$$

$$(R = R' = H)$$

$$C_6H_4OMe$$

$$CNCH_2 COOEt$$

$$NH$$

$$(R = R' = H)$$

$$R \longrightarrow CH - CH - CO \longrightarrow R' \longrightarrow HSCH_2 COOEt$$

$$R \longrightarrow CH - CH_2 - CO \longrightarrow R'$$

$$SCH_2 COOEt$$

$$(I)$$

$$R \longrightarrow S \longrightarrow R'$$

$$OH$$

$$(II)$$

100

$$i)R = R' = H$$

ii)
$$R = H$$
; $R' = 2 - (3 - and 4 -) NO2.$

Ethyl≪ -cyanobutyrate:

Chalcone undergoes Michael addition when reacted with ethyl company contracts. The kinetics of this reaction has been investigated. 16

Ethyl Thioglycolate:

Chalcone and nitrochalcones are reported 17 to react with ethyl thioglycolate, in the presence of piperidine, to yield an addition compound (I) and a cyclised product (II).

Malonic Esters:

Malonic ester^{2,18} undergoes Michael addition with chalcone in the presence of a basic catalyst viz., piperidine. The mechanism of this reaction is reported. ¹⁸ Polyfluorochalcones ¹⁹ also undergo the above-mentioned reaction, but with difficulty.

Chalcone has been found to react with malonic ester 20 in basic medium (or in the presence of a complex derived from ketal

and potassium hydroxide)^{21,22} to yield <-carbethoxy- β -phenyl- Υ -benzoyl butyric ester^{21,23} (III). Depending, however, on the conditions of experiment, other products (IV and V) can also be obtained^{23,24}

$$\phi - CH - CH_2CO \phi$$

$$CH(COOEt)_2$$

$$(III)$$

$$CO_2 \phi$$

$$CH_2CO \phi$$

$$CH_2CO \phi$$

$$CO_2Et$$

$$CO_2Et$$

$$CO_2Et$$

$$CO_2Et$$

$$CO_2Et$$

$$CO_2Et$$

$$CO_2Et$$

$$CO_2Et$$

$$CO_2Et$$

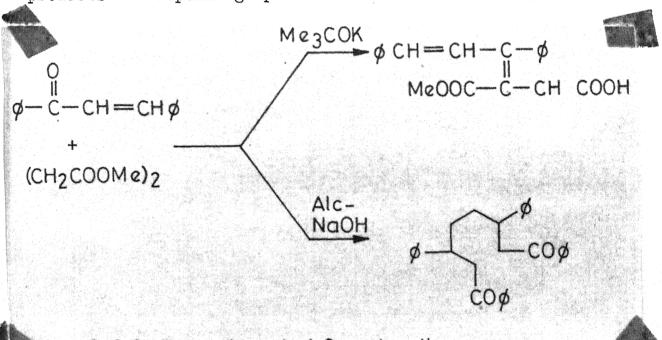
Methyl malonic ester²³, likewise adds to chalcone to yield yield -methyl-y-carbethoxy--phenyl-Y-benzoylbutyric ester²³
(VI, 80%) with larger concentration of ethoxide (1 molar), however, VI undergoes complete retrogression²³ to yield sodium enol methylmalonic ester (90%), chalcone and traces of benzoyl acetic ester. Butyric ester VI, obtained as above, but in the presence of piperidine, undergoes further reaction as illustrated²⁶:

Ethyl alkyl malonate 27 and chalcone undergo Michael condensation to give the product (alkyl = CH_3 ; 80%). In the

other case (alkyl = ethyl) the expected Michael condensation product is not isolable. This has been attributed ²⁷ to steric hindrance as well as to the instability of the Michael addition product towards sodium ethoxide present in the reaction medium.

Methyl Succinate:

Methyl succinate reacts with chalcone yielding different products 7,12 depending upon the reaction conditions. Thus:



1,3,6,8-Tetraphenyl-1,8-octandione

Dimethyl Acetylene Dicarboxylate 28:

2-Hydroxychalcone and 2,2'-dihydroxychalcone react with dimethyl acetylene dicarboxylate (DMAD) to give a mixture of phenoxymaleates (VII), phenoxyfumerates (VIII) and some cyclic products, viz., chromenes (IX) and or flavanones (X). The reaction of 3,5-dibromo-2,2'-dihydroxychalcone with DMAD is typical and is illustrated:

References

- 1. Hauser, C.R. and Abramovitch, B., J. Am. Chem. Soc., <u>62</u>, 1763 (1940).
- 2. Davey, W.A. and Gwilt, J.R., J. Chem. Soc., 1015 (1957).
- 3. Van Allan, J.A. and Reynolds, G.A., J. Org. Chem., 33, 1102 (1968).

- 4. Sammour, A-M A., El-Zimaity, M.T. and Abdel-Maksoud, A.,
 J. Chem. U.A.R., 12, 481 (1969); Chem. Abstr., 74, 42098^W
 (1971).
- 6. Joshi, U.G. and Amin, G.C., J. Indian Chem. Soc., <u>38</u>, 159 (1961).
- 7. Patwardhan, B.H., J. Indian Chem. Soc., 50, 430 (1973).
- 8. Dodwadmath, R.F. and Wheeler, T.S., Proc. Indian Acad. Sci., 2A. 438 (1935).
- 9. Hanson, G.A., Bull. Soc. Chim. Belges, <u>67</u>, 91 (1958); Chem. Abstr., <u>52</u>, 20111^d (1958).
- 10. Sammour, A., Selim, M.I.B. and Abd Elhalim, M.S., Egypt. J. Chem., <u>15</u>, 23 (1972); Chem. Abstr., <u>79</u>, 115259^q (1973).
- 11. Essawy, A. and Hamed, A.A., Indian J. Chem., 16B, 880 (1978).
- 12. Sammour, A., Raouf, A., Elkasaby, M. and Ibrahim, M.A., Acta Chem. (Budapest), <u>78</u>, 399 (1973); Chem. Abstr., <u>79</u>, 146100^k (1973).
- 13. Sammour, A., Fahmy, A.F., Abd El-Rahman, S., Akhmookh, Y. and Abd Elmoez, M.S., U.A.R., J. Chem., <u>14</u>, 581 (1971); Chem. Abstr., <u>79</u>, 115413^k (1973).
- 14. Jahine, H., Zaher, H.A., Sayed, A.A. and Sherif, O., Indian J. Chem., 11, 1122 (1973).
- 15. Abdalla, M., Essawy, A. and Deeb, A., Pak, J. Sci. Ind. Res., 20, 139 (1977).
- 16. Toma, S., Coll. Czech. Chem. Commun., 34, 2771 (1969).

- 17. Xicluna, A., Guinchard, C., Robert, J.F. and Panouse, J.J., C. R. Hebd. Seances Acad. Sci., Ser. C., <u>280</u>, 287 (1975); Chem. Abstr., <u>82</u>, 155994^u (1975).
- 18. Kinastowski, S., Kojkowicz-Balcerek, M., Grabarkiewicz, J. and Kasprzyk, H., Bull. Acad. Polon. Sci., Ser. Sci. Chim., 23, 199 (1975); Chem. Abstr., 83, 78064^g (1975).
- 19. Filler, R., Beaucaire, V.D. and Kang, H.H., J. Org. Chem., 40, 935 (1975).
- 20. Holden, N.E. and Lapworth, A., J. Chem. Soc., 2368 (1931).
- 21. Weizmann, C., U. S. Patent 2,472,135 (1949); Chem. Abstr., 43, 6665 (1949).
- 22. Weizmann, C., Brit. Patent 594,182 (1947); Chem. Abstr., <u>42</u>, 2987^b (1948).
- 23. Michael, A. and Ross, J., J. Am. Chem. Soc., 55, 1632 (1933).
- 24. Orlov, V.D., Tishcheńko, V.N., Ivanova, E.T. and Lavrushin, V.F., Zh. Org. Khim., <u>13</u>, 2142 (1977); Chem. Abstr., <u>88</u>, 104840^g (1978).
- 25. Michael, A. and Ross, J., J. Am. Chem. Soc., <u>54</u>, 407 (1932).
- 26. Connor, R. and Andrews, D.B., J. Am. Chem. Soc., <u>56</u>, 2713 (1934).
- 27. de Benneville, P.L., Clagett, D.D. and Connor, R., J. Org. Chem., <u>6</u>, 690 (1941).
- 28. Gupta, R.K. and George, M.V., Tetrahedron, 31, 1263 (1975).

CHAPTER - 4.5

REACTION OF CHALCONES WITH AMIDES

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<u>Urea</u>: Chalcone reacts, under acid catalysis, with urea to yield 2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyrimidine. Similar reaction is reported to take place with arylidene <u>bis</u> ureas.

Thiourea: 2-oxo-4,6-diphenyl-3,6-dihydro-1,3-thiazine (I) is obtained² by the reaction of chalcone with thiourea, in the presence of dilute sulphuric acid. The formation of I has been rationalized² as follows:

4-chloro-(and 4-methoxy) chalcones, however, yield their corresponding dimers², when reacted under the above conditions.

Cyanoacetamide: Chalcone condenses with cyanoacetamide to yield a nitrogen heterocycle (II)

Malonamide: Depending upon the conditions of the experiment, different products (III or IV) are formed by the reaction of chalcones with malonamide⁴.

N, N-Dibromobenzenesulphonamide 5,6:

The reaction of N,N-dibromobenzenesulphonamide with chalcones presents an interesting example. Thus different products (vide infra) are formed with variously substituted chalcones:

$$R \longrightarrow C - NHSO_{2} \phi$$

$$CHCO \phi \quad (R = H)$$

$$R \longrightarrow CO \phi$$

$$R = 2 - NO_{2} \phi$$

$$R \longrightarrow CHBr - CHBr - CO \phi$$

$$(V)$$

$$R \longrightarrow CH - CHBr - CO \phi$$

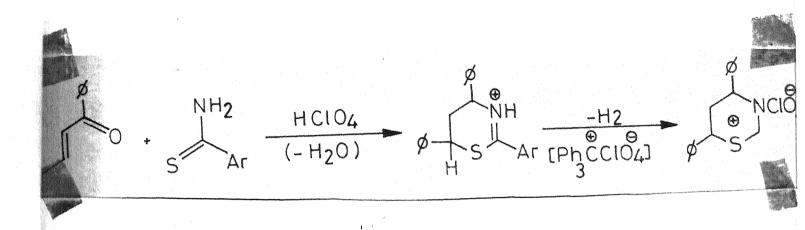
$$NHSO_{2} \phi + PhSO_{2}NH_{2}$$

$$V$$

$$R = 3 - (and 4-)NO_{2}$$

Aromatic Thioamides:

1,3-Thiazinium salts 7 derived from chalcone have been secured by the following series of reactions:



References

- Sedova, V.F., Samsonov, V.A. and Mamaev, V.P., Izv. Sib. Otd. Akad. Nauk, SSSR, Ser. Khim. Nauk, <u>2</u>, 112 (1972); Chem. Abstr., <u>77</u>, 164635^b (1972).
- 2. Dhar, D.N. and Singh, A.K., Annual Convention of Chemists Abstracts, Org-57, p. 22 (1976); Indian J. Chem., <u>17B</u>, 25 (1979).
- 3. Carrie, R. and Rochard, J.C., Compt. Rend., 257, 2849 (1963).
- 4. Sammour, A., Selim, M.I.B., Abdel Halim, M.S., Egypt. J. Chem., <u>15</u>, 23 (1972); Chem. Abstr., <u>79</u>, 115259^q (1973).
- 5. Chen, C-T., Bull. Inst. Chem., Acad. Sinica No. 15, 53 (1968);
 Chem. Abstr., 70, 77503^u (1969).
- 6. Chen, C-T. and Chen, T-K., Bull. Inst. Chem., Acad. Sinica 22, 88 (1973); Chem. Abstr., 81, 135629^e (1974).
- 7. Hartmann, H., Tetrahedron Letters, 3977 (1972).

CHAPTER - 4.6

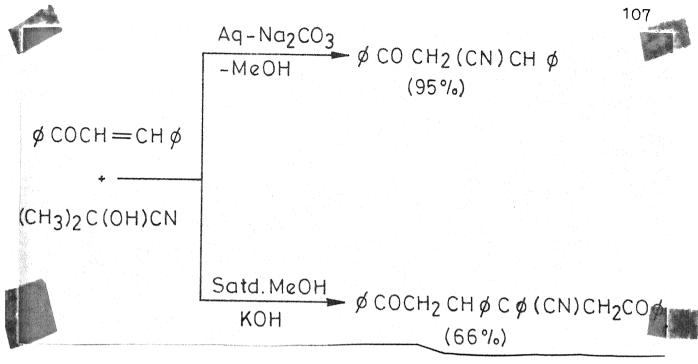
REACTION OF CHALCONES WITH CYANIDES, ISOCYANIDES AND ISOCYANATES

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Hydrocyanic acid:

Hydrocyanic acid is reported to react with chalcone to yield an adduct, \emptyset CH(CN)CH₂CO \emptyset . The adduct has been transformed into acid, lactone, pyridazinone, and diol under appropriate reaction conditions.

The exchange of hydrocyanic acid occurs between chalcone and acetone cyanohydrin² in the presence of a base. Reaction may take either of the following pathways-depending upon the condition of the experiment². Thus:



Aliphatic and Alicyclic Nitriles:

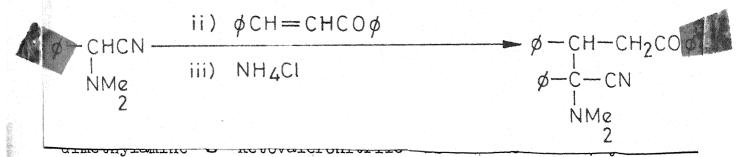
Aliphatic nitriles, RCH_2CN , add across the carbonyl group of chalcone to give β -hydroxynitriles³. Thus, acetonitrile³ reacts with chalcone in the presence of lithium amide in liquid ammonia, to give $\emptyset CH = CHC(OH)(CH_2CN)\emptyset$.

Benzonitrile and Acetonitrile:

Chalcone behaves as a less satisfactory olefin component in the Ritter reaction. Thus benzonitrile reacted with chalcone in the presence of acid, resulting in the formation of 3-benzamido-3-phenylpropiophenone⁴ in a small yield. With acetonitrile, however, the end product is an oxazine⁴:

Chalcone undergoes conjugate addition with \prec -dimethyl-aminophenyl acetonitrile, in the presence of potassium amide in liquid ammonia. The product \prec , β , ξ -triphenyl- \prec -

i)
$$KNH_2-NH_3(l)$$



Ethyl- Υ -cyano- β , Υ -diphenylbutyrate:

Chalcone reacts with the title compound, in the presence of sodium ethoxide in ethanol, to give 3-benzoyl-4-keto-1,2,6-triphenylcyclohexanenitrile⁶.

Potassium Isocyanide:

Chalcone and potassium isocyanide⁷, in boiling methanol, yield an addition product, \emptyset CH $\Big[C\emptyset(CN)CH_2-CO\emptyset \Big] CH_2CO\emptyset$, according to the following scheme:

$$\phi CH = CHCO\phi + KNC \longrightarrow \phi CH - CH = C(OK)\phi$$

$$CN$$

$$\phi - CH - CH_2 - CO\phi$$

$$CNK$$

$$\phi - CH - CH_2 CO\phi$$

$$CNK$$

$$\phi - CH - CH_2 CO\phi$$

$$\phi - C(CN) - CH_2 CO\phi$$

$$\phi - C(CN) - CH_2 CO\phi$$

Chlorosulphonyl Isocyanate:

Chlorosulphonyl isocyanate is reported⁸ to react with chalcone to yield N-chlorosulphonyl-4,6-diphenyl-2-oxo-3,4-di-hydro-1,3-oxazine (Ia, 55%); the latter compound on reduction

H
$$\downarrow$$
 0
H \downarrow N 0
R \downarrow R \downarrow (I) (a) R = SO₂CI;
(b) R = H

with thiophenol-pyridine gives I(b).

In the case of 4 (and 4')-methoxy chalcones, however, the reaction with chlorosulphonyl isocyanate leads to the formation of N-chlorosulphonylimine 9 , R'-C(=NSO₂Cl)CH=CH-R, via the unstable 1,3-oxazetidin-2-one.

References

- 1. Davey, W. and Tivey, D.J., J. Chem. Soc., 1230 (1958).
- 2. Betts, B.E. and Davey, W., J. Chem. Soc., 4193 (1958).
- Popandova, K.V., Ivanov, K., Dokl. Bolg. Akad. Nauk, <u>24</u>,
 621 (1971); Chem. Abstr., <u>75</u>, 98296^x (1971).
- 4. Scheuer, P.J., Botelho, H.C. and Pauling, C., J. Org. Chem., 22, 674 (1957).
- 5. Taylor, H.M. and Hauser, C.R., J. Am. Chem. Soc., <u>82</u>, 1790 (1960).
- 6. Helmkamp, R.W., Tanghe, L.J. and Plati, J.T., J. Am. Chem. Soc., <u>62</u>, 3215 (1940).
- 7. Michael, A. and Weiner, N., J. Am. Chem. Soc., <u>59</u>, 744 (1937).
- 8. Dhar, D.N., Mehta, G. and Suri, S.C., Indian J. Chem., <u>14B</u>, 477 (1976).
- 9. Dhar, D.N. and Suri, S.C., Indian J. Chem., 18B, 281 (1979).

CHAPTER - 4.7

REACTION OF CHALCONES WITH AMINES

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Methylamine:

N,N-bis (\ll -phenacylbenzyl) methylamine, [CH₃N (-CHØ) CH₂COØ)₂ results by the interaction of chalcone with methylamine in ethanolic solution.

Methoxyamine:

Methoxyamine² reacts with chalcone and its p- or p' substituted analogue to give the addition product, β -methoxy-aminopropiophenone and β β '-methoxyimino-bis-propiophenone. In the presence of strong base, the addition product obtained, for example in the case of chalcone, undergoes rearrangement² to yield \sim -aminochalcone (94%)

$$\emptyset \text{CH} = \text{CHCO}\emptyset + \text{CH}_3 \text{ONH}_2 \longrightarrow \emptyset \text{CHCH}_2 \text{CO}\emptyset$$

$$\text{NHOCH}_3 \quad (64\%)$$

$$\emptyset - \text{CH} - \text{CH}_2 \text{CO}\emptyset$$

$$\emptyset \text{CH} = \text{C} - \text{CO}\emptyset$$

$$\text{NHOCH}_3$$

$$\text{NH}_2 \qquad \emptyset - \text{CH} - \text{CH}_2 \text{CO}\emptyset$$

Aziridines have been prepared from chalcones in the

MeO-
$$C_6H_4COCH = CH\phi \xrightarrow{MeONH_2} - MeO-C_6H_4COCH_2-$$

CH(NHOMe) $\phi \xrightarrow{NaOMe/MeOH} - MeO-C_6H_4CO-CH-CH-\phi$

National Meo- $C_6H_4CO-CH-CH-\phi$

National Meo- C_6H_4CO-CH

The addition product, β -anilino-benzylacetophenone⁴, is formed by the reaction of chalcone with aniline. In the case of other primary aromatic amines, the addition of the hydrochloride salt of the amine is preferred⁵ and the yields of products range from 27-55%.

Nitromethylchalcones have been reported⁶ to react with p-nitro-N,N-dimethylaniline (NDA), illustrating the reaction capacity of the methyl group.

$$\frac{\text{Me}_{2N}}{\text{O}_{2N}} = \text{CH}_{O_{2N}} = \text{CH}_{O_{2$$

1-Cyano-2-Methyl-2-aminoethylene:

3-cyano-4-phenylpyridines have been secured by the reaction of 1-cyano-2-methyl-2-aminoethylene with chalcones, which have been subsequently transformed into 2-azafluorenones⁷.

Aminobenzenethiol:

Two products are formed in the reaction of -aminobenzenethiol with chalcone, viz., β -phenyl- β (o-aminophenylmercapto) propiophenone and its cyclised product: 2,4-diphenyl-6,7-benzo-1-thia-5-aza-4,6-cycloheptadiene⁸:

SH +
$$\phi$$
 CH = CHCO ϕ Piperidine $\begin{array}{c} SCH(\phi) CHCO\\ 2\\ NH_2 \end{array}$ + $\begin{array}{c} SCH(\phi) CHCO\\ 2\\ NH_2 \end{array}$

Pyrrolidine:

The reaction of <u>cis-</u> and <u>trans-chalcones</u> with pyrrolidine has been investigated⁹. It has been shown⁹ that <u>cis-chalcone</u> changes to the corresponding <u>trans-isomer</u> (vide <u>infra</u>) before yielding the Michael adduct:

$$\phi - C$$

$$\phi - C$$

$$H$$

$$+ NH(CH2)4
$$+ O$$

$$H$$

$$H$$

$$+ O$$

$$+ O$$$$

Iodine-amine Complexes:

Ethyleneimine ketones 10 are formed by the action of iodine complexes of ammonia or primary amines with chalcones. \ll , β -Diaminobenzylacetophenone, however, are produced when chalcone is reacted with a secondary amine-iodine complex.

It has been observed 11 that in the preparation of ethyleneimine ketone, the nature of solvent has a decisive influence upon the configuration of the end product. For example 11, the reaction of trans-chalcone with cyclohexylamine iodine complex, in methanolic solution yields 88% of trans-1-cyclohexyl-2-phenyl-3benzoylethyleneimine as compared to 61-73% in benzene. On the other hand, substitution of methanol for benzene in reaction of cyclohexylamine with trans-&-bromochalcone greatly increased the proportion of cis-ethyleneimine ketone.

Ortho-substituted chalcone react with amines, 12,13 in the presence of iodine, to give different products, depending upon the nature of the 2'-substituent. The following table illustrates

the various products that are formed: CHCI-CH(NHR')-NH C6H11

Triaminoguanidine Salt:

The reaction of chalcone with triaminoguanidine 14 is slow, and yields the corresponding hydrazone (75%) of the type: (RR'C = NNH)₂ C = N-N = CRR', where R = Phenyl and R' = Styryl groups respectively.

Amidines 15,16;

Amidine hydrochloride is reported to react with chalcone to yield the cyclo-addition product, viz., 2,4,6-triphenylpyrimidine,

ketone.

References

- 1. Cromwell, N.H. and Caughlan, J.A., J. Am. Chem. Soc., <u>67</u>, 2235 (1945).
- 2. Blatt, A.H., J. Am. Chem. Soc., 61, 3494 (1939).
- 3. Drefahl, G., Ponsold, K. and Schoenecker, B., Chem. Ber., <u>97</u>, 2014 (1964).
- 4. Cromwell, N.H., Wiles, Q.T. and Schroeder, O.C., J. Am. Chem. Soc., <u>64</u>, 2432 (1942).
- 5. Kozlov, N.S. and Shur, I.A., Zh. Obshch. Khim., <u>30</u>, 2746 (1960).
- 6. Chardonnens, L. and Venetz, J., Helv. Chim. Acta, <u>22</u>, 1278 (1939).
- 7. Chatterjee, J.N. and Prasad, K., J. Sci. Ind. Research (India), 14B, 383 (1955).
- 8. Stephens, W.D. and Field, L., J. Org. Chem., 24, 1576 (1959).
- 9. Menger, F.M. and Smith, J.H., J. Am. Chem. Soc., 91, 4211 (1969).
- 10. Southwick, P.L. and Christman, D.R., J. Am. Chem. Soc., <u>74</u>, 1886 (1952).
- 11. Southwick, P.L. and Shozda, R.J., J. Am. Chem. Soc., <u>82</u>, 2888 (1960).
- 12. Bognar, R., Litkei, G. and Szigeti, P., Acta Chim. (Budapest), 68, 421 (1971); Chem. Abstr., 75, 35620° (1971).
- 13. Litkei, G., Bognar, R., Szigeti, P. and Trapp, V., Acta Chim. (Budapest), 73, 71 (1972); Chem. Abstr., 77, 88219b (1972).

- 14. Scott, F.L., Cashman, M. and Reilly, J., J. Am. Chem. Soc., 75, 1510 (1953).
- 15. Dodson, R.M. and Seyler, J.K., J. Org. Chem., 16, 461 (1951).
- Vais, A.L., Shyrina, V.M. and Mamaev, V.P., Izv. Sib. Otd.
 Akad. Nauk SSSR, Ser. Khim. Nauk, (6), 144 (1975); Chem.
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CHAPTER - 4.8

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A. Reaction with Organometallic Compounds

Lithium Acetylide:

The reaction of chalcone with lithium acetylide in liquid ammonia yields the corresponding ethynyl carbinol 1 (1:2-adduct) in a good yield (81%).

Phenyl-alkali Metals:

Phenyl lithium, phenyl sodium and phenyl potassium react with chalcone to yield mainly the 1,2-addition products² (60-75%):

The mode of addition of the organometallic compound to chalcone depends upon the reactivity of the former. In these cases, the addition may occur either across the double bond and/or the carbonyl group of chalcone molecule. The following examples are illustrative:

$$g$$
COCH=CH- g
 g C(OH)CH=CH g (52%)

(I)

 g COCH=CH- g
 g L

 g L

 g L

 g C(OH)CH=CH g (52%)

(II)

Reaction with excess phenyl lithium is reported⁴ to yield 1,1,2,3,3-pentaphenyl propanol besides the diphenyl styryl carbinol (I).

Phenyl lithium is also reported⁵ to add to $\underline{\text{trans}}$ - \propto -phenylchalcone (III), yielding 33% of the 1,4-addition product (IV) and 48% of the 1,2-addition product:

Low temperature reaction of chalcone with phenyl lithium, followed by decomposition of the reaction-mixture with water gives two products⁶, viz., PhCH=CHCPh₂CH (84%) and Ph₂CH=CH₂COPh (16%) respectively.

Benzhydryl Sodium:

Chalcone reacts with benzhydryl sodium according to the following reaction:

Aryl Copper:

Chalcone reacts with aryl copper 8 in the presence of aryl iodide, under Ullmann conditions, to give among other products, β -aryl chalcone in small amounts.

Diphenyl Beryllium:

Diphenyl beryllium reacts with chalcone to give $PhCOCH_2CHPh_2$ in a high yield (~90%).

Diphenyl Mercury:

Diphenyl mercury reacts with chalcone in the manner indicated:

Triphenyl Aluminium, Triphenyl Indium and Triphenyl Thallium:

 $\beta\beta$ -Diphenylpropiophenone is obtained when chalcone is reacted with triphenyl aluminium or triphenyl indium. Under the same reaction conditions, triphenyl thallium, however, yields an additional product, viz., β -phenyl-Y-benzhydryl-butyrophenone (30%).

Triphenyl Methyl Sodium:

The title reagent is reported⁴ to react with chalcone to yield 2,3,3,3-tetraphenylpropyl phenyl ketone (25-35%).

Triphenyl-cadmium-lithium:

Chalcone and triphenyl-cadmium-lithium 13 react to give, after hydrolysis, three products, viz., diphenylpropiophenone (21%), diphenyl styryl carbinol (6%) and β -phenyl- γ -benzoyl- γ -benzhydrylbutyrophenone (1.8%).

Triphenyl-tin-lithium:

Tetraphenyl-tin¹⁴ (7.8%) is produced in the reaction of chalcone with triphenyl tin lithium.

Tetraphenyl boro-copper:

The pyridine salt of tetraphenyl boro-copper 15 and chalcone after reaction furnish $\beta\beta$ -diphenylpropiophenone (29%).

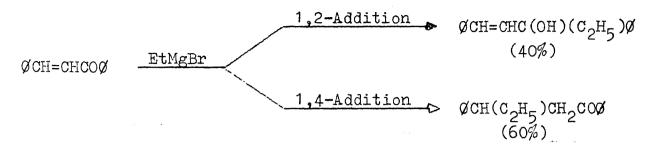
B. Reaction With Organo-magnesium Compounds

Methyl Magnesium Bromide:

Chalcone reacts with excess of methyl magnesium bromide to yield the 1,4-addition product, β -phenyl-butyrophenone 16,17 or the bimolecular compound. Sometimes a secondary product, viz., 1,3,5-triphenyl-4-benzoylhex-1,3-diene is obtained.

Ethyl Magnesium Bromide:

The products formed in the reaction of chalcone with ethyl magnesium bromide corresponds to 1,2- and 1,4-addition.



The effect of some metallic chlorides on the reaction of chalcone with Grignard reagents is reported. ¹⁶ For the formation of reduction dimers, cobalt chloride acts as a powerful catalyst compared to cuprous and ferric chlorides.

n-Butyl Magnesium Bromide:

The relative activities of chalcones, carrying an < - or β -methyl substituents towards <u>n</u>-butyl magnesium bromide have been studied. 18 β -Methyl compounds are reported 18 to be more reactive in comparison to their <-isomers.

Phenyl Magnesium Bromide:

The reaction of the <u>trans</u> chalcone with two equivalent of phenyl magnesium bromide yields two products, viz., 3,3-diphenyl-propiophenone 19,20 (83%) and <u>trans-1,1,3-triphenyl-2-propen-1-ol</u> (6%) respectively. However, a different product, 21 viz., 1,1,3,3-tetraphenyl-1-propanol results by varying the experimental conditions in the above reaction. Variation in the manner of work-up of the Grignard reaction mixture, namely the treatment with dry ice, is reported 21,22 to yield 2-benzhydryl-3-hydroxy-3,3-diphenylpropionic acid.

The mode of addition of phenyl magnesium bromide to chalcone depends upon the chemical nature of the substituents. Thus, the principal product of the reaction with 4-carboethoxychalcone is a saturated ketone, while in the case of 4-dimethylaminochalcone, the product is an \propto , β -unsaturated alcohol. 23

Organo-magnesium Compounds:

The Grignard reaction of <u>trans</u> chalcone with $Me_2CHCH_2COCHXCHMe$ (X = Cl, Br) and $Me_2CHCH_2COCH(CHMe_2)_2Mg$ is reported²⁴ to give two diastereoisomeric diketones (VI and VII)

The reaction of various magnesium carbonyls with <u>trans</u>-chalcone has been studied.²⁵ Whether the addition occurs at carbonyl or olefinic sites of chalcone, depends upon the nature of the added nucleophile.

Amino-magnesium Compounds:

Dypnopinacols (50-70%) have been secured²⁶ by the interaction of chalcones with dypnones under the influence of an amino-magnesium compound.

References

- 1. Oroshnik, W. and Mebene, A.D., J. Am. Chem. Soc., 71, 2062 (1949).
- 2. O'Sullivan, W.I., Swamer, F.W., Humphlett, W.J. and Hauser, C.R., J. Org. Chem., <u>26</u>, 2306 (1960).
- 3. Gilman, H. and Kirby, R.H., J. Am. Chem. Soc., <u>63</u>, 2046 (1941).
- 4. Michael, A. and Saffer, C.M. (Jr.), J. Org. Chem., <u>8</u>, 60 (1943).
- 5. Lutz, R.E. and Rinker, E.H. (Jr.), J. Am. Chem. Soc., <u>77</u>, 366 (1955).
- 6 Luttringhaus, A. and Scholtis, K., Ann., <u>557</u>, 70 (1945).
- 7. Bergmann, E., J. Chem. Soc., 412 (1936).
- 8. Treblow, M.D., Dissertation Abstr., Int. B., 34, 148 (1973).
- 9. Koton, M.M. and Zorina, T.M., Zh. Obshch. Khim., 19, 1137 (1949).
- 10. Wittig, G. and Bub, O., Ann., 566, 113 (1950).
- 11. Gilman, H. and Jones, R.G., J. Am. Chem. Soc., <u>62</u>, 2353 (1940).
- 12. Gilman, H. and Jones, R.G., J. Am. Chem. Soc., <u>61</u>, 1513 (1939).
- 13. Wittig, G., Meyer, F.J. and Lange, G., Ann., 571, 167 (1951).
- 14. Gilman, H. and Rosenberg, S.D., J. Org. Chem., <u>18</u>, 1554 (1953).
- 15. Sazonova, V.A. and Nazarova, I.I., Zh. Obshch. Khim., <u>26</u>, 3440 (1956).

- 16. Kharasch, M.S. and Sayles, D.C., J. Am. Chem. Soc., <u>64</u>, 2972 (1942).
- 17. Filler, R., Beaucaire, V.D. and Kang, H.H., J. Org. Chem., 40, 935 (1975).
- 18. Tsuruta, T. and Yasuda, Y., J. Macromol. Sci. Chem., 2, 939 (1968).
- 19. Dupre, R.A., Dissertation Abstr., B, 30, 556 (1969).
- 20. Sammour, A. and Elkasaby, M., U.A.R., J. Chem. Soc., <u>13</u>, 409 (1971); Chem. Abstr., <u>77</u>, 101261^f (1972).
- 21. Fuson, R.C., San, T. and Diekmann, J., J. Org. Chem., <u>27</u>, 1221 (1962).
- 22. Diekmann, J., Dissertation Abstr., 20, 4518 (1960).
- 23. MacLean, I.S. and Widdows, S.T., J. Chem. Soc., <u>105</u>, 2169 (1914).
- 24. Gorrichon-Guigon, L., Maroni-Barnaud, Y., Maroni, P. and Bastide, J.D., Bull. Soc. Chim. France (1-2, pt. 2) 291 (1975).
- 25. Bertrand, J., Gorrichon-Guigon, L., Koudsi, Y., Perry, M. and Maroni-Barnaud, Y., C. R. Acad. Sci., Ser. B., 277, 723 (1973).
- 26. Ivanov, D. and Ivanov, C., Chem. Ber., <u>76B</u>, 988 (1943).

CHAPTER - 4.9

REACTION OF CHALCONES WITH HALOGENS, PSEUDO-HALOGENS AND INTER-HALOGEN COMPOUNDS

Chlorine 128
Bromine
Kinetics of Bromine Addition 129
Debromination of Chalcone Dibromides 129
Iodine Monochloride
Bromine Fluoride and Bromine Chloride
Chlorine Thiocyanate, Thiocyanogen and Iodine Thiocyanate 131
References

Chlorine:

Chalcone reacts with chlorine to yield two stereoisomeric chalcone \propto , β dichlorides. The dichlorides 2,3, under appropriate reaction conditions are convertable to \sim -chlorochalcone (80%).

Bromine:

A large number of chalcone \ll , β dibromides have been prepared. 3-13 Bromination is effected either by the reaction of bromine 3-9,11-13 (in carbon disulphide or acetic acid), tetrabromo-o-benzoquinone 10 1-bromo-2-methyl-2-imidazoline hydrobromide 14 or 1,3-dibromo-5,5'-dimethylhydantoin 15 on

chalcones. The reaction with bromine is sometimes attended with nuclear bromination $^{11-13}$ (ring A and/or ring B of chalcone) depending upon the reaction conditions employed.

Kinetics of Bromine Addition:

The kinetics of bromine addition to chalcone and its derivatives have been investigated 16,17 and a two-step mechanism of this reaction has been proposed 18:

$$\phi$$
 -C- CH = CH ϕ + Br2 = ϕ -C - CH-CH- ϕ - Br

Debromination of Chalcone Dibromides:

Chalcone \propto , β dibromides on treatment with potassium iodide in acetone are reported^{3,7} to undergo debromination to yield the respective chalcones. Debromination has been achieved¹⁹ by reacting the chalcone dibromide with stannous chloride in various solvents, viz., acetone, tetrahydrofuran and dimethylformamide.

In a methanolic solution, chalcone reacts with bromine (at 25-30°) to give a mixture of two products, 20,21 viz., \swarrow -bromo- β -methoxy- β -phenylpropiophenone (23%) and chalcone \swarrow , β -dibromide (5%). The yield of the former product is raised if the reaction is conducted at higher temperature (65°). Likewise \swarrow -chloro- β -

methoxy- β -phenylpropiophenone²¹ has been secured in 56% yield by conducting the reaction of chalcone with chlorine (in methanol) at 25-30°. The mechanism of the reaction has been postulated²¹ as follows:

$$X_2 + CH_3OH \longrightarrow CH_3OX + HX$$

(X = Cl, Br)

 $\emptyset - \infty CH = CH - \emptyset + CH_3OX \longrightarrow \emptyset COCHX - CH(OCH_3) - \emptyset$

Iodine Monochloride:

Treatment of chiral crystals of 4,4'-dimethylchalcone with chlorine, bromine or iodine monochloride is reported²² to yield optically active dihalides. The reaction of iodine chloride and 2'-hydroxychalcone has been shown²³ to yield products depending upon the nature of substituent(s). Thus iodine chloride reacts with 2'-hydroxy-3',5'-dimethyl-4-methoxychalcone to yield 3-iodo-6,8-dimethylflavanone. Chalcone lacking in strong electron donor substituent (e.g., methoxy), however, undergoes addition reaction with iodine chloride. Nevertheless, nuclear haloganation, in preference to addition reaction, is reported to occur in one case, viz., 2'-hydroxy-4',6'-dimethoxychalcone.

Bromine Fluoride and Bromine Chloride:

Bromine fluoride²⁴ and bromine chloride²⁵ are reported to add to the olefinic double bond of chalcone molecule, thus:

$$\begin{array}{c} O \\ \parallel \\ - C - CH = CH - \\ \hline \end{array} \begin{array}{c} R^2 + BrX \longrightarrow R' - \\ \hline \end{array} \begin{array}{c} O \\ \parallel \\ - C - CHBr - CHX - \\ \hline \end{array} \begin{array}{c} O \\ \parallel \\ - C - CHBr - CHX - \\ \hline \end{array}$$

Chlorine Thiocyanate, Thiocyanogen and Iodine Thiocyanate:

chlorine thiocyanate, thiocyanogen and iodine thiocyanate 26 add across the double bond of chalcone molecule. From the addition products, obtained in the first two cases, ad-thiocyanatochalcones
have been secured by dehydrohalogenation.

References

- 1. Abell, R.D. and Siddall, W., J. Chem. Soc., 2804 (1953).
- 2. Auwers, K.V. and Hugel, R., J. Prakt. Chem., 143, 157 (1935).
- 3. Dodwadmath, R.P. and Wheeler, T.S., Proc. Indian Acad. Sci., 2A, 438 (1935).
- 4. Abell, R.D., J. Chem. Soc., 101, 998 (1912).
- 5. Allen, C.F.H., Normington, J.B. and Wilson, C.V., Can J. Research, <u>11</u>, 382 (1934).
- 6. Filler, R., Beaucaire, V.D. and Kang, H.H., J. Org. Chem., 40, 935 (1975).
- 7. Merchant, J.R. and Choughuley, A.S.U., Current Sci. (India), 29, 93 (1960).
- 8. Kanthi, R.B. and Nargund, K.S., J. Karnatak Univ., 2, 8 (1957); Chem. Abstr., 53, 8067^b (1959).

- 9. Ambekar, S.Y., Jolad, S.D. and Rajagopal, S., Monatsh. Chem., 92, 1303 (1961).
- 10. Latif, N. and El-Bayouki, K., Chem. and Ind. (London), 316 (1975).
- 11. Chhaya, G.S., Trivedí, P.L. and Jadhav, G.V., J. Univ. Bombay, <u>26A</u>, Part 3, 16 (1957); Chem. Abstr., <u>53</u>, 10125^b (1959).
- 12. Chhaya, G.S., Trivedi, P.L. and Jadhav, G.V., J. Univ. Bombay, 27A, Part 3, 26 (1958); Chem. Abstr., 54, 8807^e (1960).
- 13. Wagh, S.P. and Jadhav, G.V., J. Univ. Bombay, <u>27A</u>, Part 3, 1 (1959); Chem. Abstr., <u>54</u>, 6707^f (1960).
- 14. Tsuchiya, C., Nippon Kagaku Zasahi, <u>82</u>, 723 (1961); Chem. Abstr., <u>59</u>, 599^d (1963).
- 15. Giovambattista, N., Rabassa, R.J. and Orazi, O.O., Anales asoc. quím. Argentina, 39, No. 191, 31 (1951); Chem. Abstr., 47, 2732^a (1953).
- 16. Mohapatra, S.N., Mohapatra, P.K., Nayak, P.L. and Rout, M.K., J. Indian Chem. Soc., 49, 135 (1972).
- 17. Rothbaum, H.P., Ting, I. and Robertson, P.W., J. Chem. Soc., 980 (1948).
- 18. Rout, N., Nayak, P.L. and Rout, M.K., J. Indian Chem. Soc., 47, 217 (1970).
- 19. Ghiya, B.J., Indian J. Chem., 9, 502 (1971).
- 20. Conant, J.B. and Jackson, E.L., J. Am. Chem. Soc., <u>46</u>, 1727 (1924).
- 21. Jackson, E.L., J. Am. Chem. Soc., 48, 2166 (1926).

- 22. Green, B.S. and Heller, L., Science, 185 (4150), 525 (1974).
- 23. Weber, F.G. and Brosche, K., Z. Chem., 9, 341 (1969).
- 24. Weber, F.G., Giese, H. and Westphal, G., Z. Chem., <u>15</u>, 475 (1975).
- 25. Weber, F.G. and Reimann, E., Z. Chem., 12, 176 (1972).
- 26. Weber, F.G., Holzenger, A., Westphal, G. and Puseh, U., Pharmazie, 30, 800 (1975); Chem. Abstr., 84, 89760^c (1976).

CHAPTER - 5

CYCLISATION REACTIONS OF SUBSTITUTED CHALCONES

Formation of Flavanones
Formation of Benzylidene-Coumaranones, Chromones and
Chromanones
Flavonols, Aurones and Dihydroflavonols
Flavones
Isoflavones141
Cyclisation of 2'-hydroxy-2-nitrochalcone142
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Formation of Flavanones:

The conversion of substituted 2'-hydroxychalcones into their corresponding flavanones is usually effected under the influence of mineral acids. 1-16 The optimum time of reaction, in the presence of phosphoric acid, has been reported to be in the range of 20-30 hours. The reaction time, however, varies with the nature of alcohol used as a solvent. Higher alcohols are not suitable since these promote side reactions. The yield of flavanones is, by and large, independent of the concentration of phosphoric acid.

The preparation of \underline{d} -7-hydroxyflavanone has been achieved by heating 2',4'-dihydroxychalcone with \underline{d} -camphorsulphonic acid. The temperature and duration of heating are reported to be important factors for the production of maximum optical activity.

Some of the hydroxynitro chalcones (bearing a 2'-hydroxyl) have been cyclised to their corresponding flavanones. The chelation of the nitro group with 2'-hydroxyl is an important parameter in determining the stability of chalcone in respect of its conversion to flavanone.

Oftentimes dilute alkali has been used 17,18 to bring about the cyclisation of polyhydroxychalcones (taking butein as an example) into their corresponding flavanones. The synthesis of several flavanones and 3-benzylidene flavanones, using appropriately substituted chalcones as the starting materials, are reported in the literature. 19-32,37,38

The quantitative influence of substituent effects on the cyclisation kinetics of 2'-hydroxychalcone into flavanone has been studied. 33 Reaction mechanisms have been proposed 34-36 for this type of transformation.

The <-or β -cyclisation of chalcone to yield aurone or flavanones depends upon the nature of the <-substituent (with respect to the carbonyl group) and pH of the reaction medium.

Amongst the parameters regulating the β -cyclisation includes the stability of the resulting flavanones, acidity of the 3-protons and the presence of a 5-hydroxylic function.

Formation of Benzylidene Coumaranones, Chromones and Chromanones:

Under appropriate reaction conditions hydroxychalcones have been transformed into benzylidene-coumaranones⁴⁰⁻⁴² and hydroxychromones.^{43,44}

By carrying out the AFO reaction on 2'-hydroxychalcones, containing an \propto -phenyl substituent, the synthesis of chromanones has been achieved.

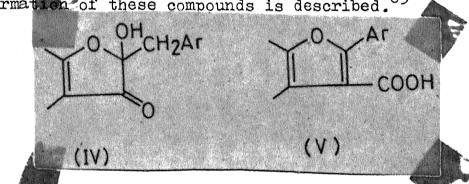
Formation of Flavonols 11,12,25,26,40-42,46-51,67,70,89,90 Aurones and Dihydroflavonols 64:

2'-Hydroxychalcones on oxidation with alkaline hydrogen peroxide give flavonols. 11-13,40-42,46-54 This reaction is often referred to as Algar-Flynn-Oyamada (AFO) reaction. However, if there is a methoxy 55 or methyl substituent at 6'-position in chalcone, 55-57 aurones are formed, provided there is no hydroxylic function present at 2- or 4-positions 58,59 and that the reaction is carried out at room temperature. An aurone derivative (I) isolated in the AFO reaction of 2'-hydroxy-4,4',6'-trimethoxychalcone has been shown to have an erythro configuration.

In some cases, however, mixture of aurone and flavonol are obtained. 61 For example:

Similar results have been reported⁶² in respect of 2',4'-dihydroxy-3'-nitro-dihydroxy-3'-nitro-chalcone (II) and 2',6'-dihydroxy-3'-nitro-chalcone (III) when these are treated with pyridine and alkaline hydrogen peroxide. Thus, under these reaction conditions, II yield 7-hydroxy-8-nitroflavonol⁶² and III gives the corresponding aurone.⁶² The chalcone bearing a nitro substituent (X=NO₂) however, fails to undergo the AFO reaction.⁶¹

Two additional products (IV and V) are reported 63,64 to be formed in the AFO reaction of chalcone. The rationale for the formation of these compounds is described.65



A detailed mechanism of AFO reaction has been published. 66

Flavanones 24,25 can also be converted into flavonols, with alkaline hydrogen peroxide. In this case the reaction is reported 24-25 to proceed through the intermediacy of 2'-hydroxy-chalcone and dihydroflavonol.

Hydroxyflavonols⁶⁷ have been secured by the rearrangement of <-nitrochalcone epoxides.</pre>

The geometric isomers of dihydroxyflavonols have been prepared. 68 The following sequence of steps were employed, for example, in the synthesis of <u>cis</u> and <u>trans-3',4';7-trimethoxy-dihydroflavonols</u>.

Formation of Flavones:

Flavones have been prepared from appropriately substituted chalcones either by their oxidation with selenium dioxide, 13,23,31,69-81 or by heating with palladium black. 82,83 Cirsimaritin — a flavone derivative, for example, has been secured 1 by the reaction of 2'-hydroxy-4-benzoyloxy-4',5',6'-trimethoxychalcone with selenium dioxide, followed by debenzoylation and partial demethylation. The syntheses of naturally occurring flavones, 74 viz., cirsiliol and cirsilineol are based

on the aforesaid reaction. 7-Hydroxyflavone, on the other hand, has been secured ⁸² in 35% yield by heating (at 220°) 2',4'-dihydroxychalcone with palladium.

An alternative method⁸⁴ of preparing flavones in high yield, consists in the reaction of 2'-hydroxychalcone (sodium salt) with lithium chloropalladite (LCP). The following mechanism has been postulated for the reaction.

obtained as a mixture of <u>axial</u> and <u>equitorial</u> isomers, from 2'-hydroxy-4-methoxychalcones by initial bromination, followed by iodine catalysed cyclisation of the resulting chalcone dibromide.

Formation of Isoflavones:

Two approaches 85-87 have been made for effecting the synthesis of isoflavones and are illustrated by the following two examples:

3',7-Dihydroxy-4'-methoxyisoflavone has been prepared⁸⁵ by the following series of reactions:

Formation of Isoflavones:

Two approaches 85-87 have been made for effecting the synthesis of isoflavones and are illustrated by the following two examples:

3',7-Dihydroxy-4'-methoxyisoflavone has been prepared⁸⁵ by the following series of reactions:

The naturally occurring 2',3',4',6,7-pentamethoxy- and 2',4',5',6,7-pentamethoxy isoflavones have been secured by the action of thallic nitrate on appropriately substituted chalcones.

Cyclisation of 2'-hydroxy-2-nitro-5'-methyl chalcone 88:

The title compound undergoes cyclisation in the presence of caustic alkali, to yield 10-hydroxy-2-methyl-11H[1]benzopyrane [3,2-b]-indole 11-one, (VI). Treatment of the latter with sulphur dioxide in methanol yields the following

(VII)

13. Naik, H.B., Mankiwala, S.C. and Thakor, V.M., J. Indian Chem. Soc., <u>52</u>, 1099 (1975).

99795^a (1971).

- 14. Matsuura, S., Iinuma, M., Ito, T., Kuroiwa, M. and
 Higashi, N., Yakugaku Zasshi, 96, 393 (1976); Chem. Abstr.,
 85, 5455^a (1976).
- 15. Soni, V.T., Shah, R.V. and Amin, G.C., Vidya, <u>19B</u>, 205 (1976); Chem. Abstr., 88, 50598^p (1978).
- 16. Yamato, M. and Hashigaki, K., Japan Kokai Tokkyo Koho 78121763 (1978); Chem. Abstr., 90, 87277^a (1979).
- 17. Saiyad, I.Z., Nadkarni, D.R. and Wheeler, T.S., J. Chem. Soc., 1737 (1937).
- 18. Anteunis, M., Verhandel. Koninkl. Vlaam. Acad. Wetenschap., Belg., Kl. Wetenschap., 22, No. 64, 1 (1960); Chem. Abstr., 55, 19917^g (1961).
- 19. Raval, A.A. and Shah, N.M., J. Org. Chem., 21, 1408 (1956).
- 20. Dhar, D.N. and Lal, J.B., J. Org. Chem., 23, 1159 (1958).
- 21. Szell, T., Chem. Ber., 91, 2609 (1958).
- 22. Mulchandani, N.B. and Shah, N.M., Chem. Ber., <u>93</u>, 1918 (1960).
- 23. Awad, W.I., El-Neweihy, M.F. and Selim., S.F., J. Org. Chem., 25, 1333 (1960).
- 24. Dhar, D.N., J. Org. Chem., 25, 1247 (1960).
- 25. Reichel, L. and Steudel, J., Ann., 553, 83 (1942).
- 26. Reichel, L. and Marchand, J., Chem. Ber., 76B, 1132 (1943).
- 27. Reichel, L. and Schickle, R., Chem. Ber., 76B, 1134 (1943).
- 28. Bognar, R., Tokes, A.L. and Frenzel, H., Acta Chim.
 (Budapest), 61, 79 (1969); Chem. Abstr., 71, 113217k
 (1969).

- 29. Bognár, R., Farkas, I. and Rakoshi, M., Acta Chim. Acad. Sci., Hung., 30, 87 (1962); Chem. Abstr., 58, 4635° (1963).
- 30. Aurnhammer, G., Wagner, H., Horhammer, L. and Farkas, L., Chem. Ber., <u>104</u>, 473 (1971).
- 31. Mahal, H.S., Rai, H.S. and Venkataraman, K., J. Chem. Soc., 866 (1935).
- 32. Balaiah, V., Row, L.R. and Seshadri, T.R., Proc. Indian Acad. Sci., <u>201</u>, 274 (1944).
- 33. Grouiller, Λ. and Thomassery, V., Bull. Soc. Chim. France,

 12, pt. 2, 3448 (1973); Chem. Abstr., 81, 12959⁶ (1974).
- 34. Lin, C-H. and Chen, F-C., Formosan Sci., <u>12</u>, 5 (1958); Chem. Abstr., <u>53</u>, 7159^h (1959).
- 35. Panasenko, A.I., Kachurin, O.I. and Starkov, S.P., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., <u>18</u>, 1203 (1975); Chem. Abstr., <u>83</u>, 205454^m (1975).
- 36. Panasenko, A.I., Izv. Vyssh. Ucheb. Zaved., Khim. Khim.
 Tekhnol., 20, 1786 (1977); Chem. Abstr., 88, 104325^t (1978).
- 57. Seikel, M.K., Lounsbury, M.J. and Wang, S.C., J. Org. Chem., <u>27</u>, 2952 (1962).
- 38. Welcomme, N., Lesieur, D., Lespagnol, C., Rabaron, Λ. and Navarro, J., Λnn. Pharm. Fr., <u>36</u>, 135 (1978); Chem. Λbstr., <u>89</u>, 190991^g (1978).
- 39. Ferreira, D., Bradt, E.V., Volstedt, F. du R. and Roux, D.G., J. Chem. Soc. Perkin Trans., 1, 1437 (1975).
- 40. Naik, V.G. and Marathey, M.G., J. Univ. Poona, Science & Technol., 18, 61 (1960); Chem. Abstr., 55, 1599^a (1961).

- 41. Gore, K.G., Naik, V.G. and Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 65 (1960); Chem. Abstr., <u>55</u>, 1599^e (1961).
- 42. Gore, K.G., Naik, V.G. and Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 69 (1960); Chem. Abstr., <u>55</u>, 1599^h (1961).
- 43. Raut, K.B., Dissertation Abstr., 20, 97 (1959).
- 44. Raut, K.B. and Wender, S.H., J. Org. Chem., <u>25</u>, 50 (1960).
- 45. Cullen, W.P., Donnelly, D.M.X., Keenan, A.K., Keenan, P.J. and Ramdas, K., J. Chem. Soc., Perkin Trans., I, 1671 (1975).
- 46. Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 53 (1960); Chem. Abstr., <u>55</u>, 1598^e (1961).
- 47. Naik, V.G. and Marathey, M.G., J. Univ. Poona, Science & Technol., 18, 55 (1960); Chem. Abstr., 55, 1598^e (1961).
- 48. Gore, K.G., Sonaware, H.R., Thankar, G.P. and Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 73 (1960); Chem. Abstr., <u>55</u>, 1600^c (1961).
- 49. Jacob, K.C., Jadhav, G.V. and Vakharia, M.N., Pesticides, <u>7</u>, 23 (1973).
- 50. Vernekar, S.S. and Rajagopal, S., Rec. Trav. Chim., <u>81</u>, 710 (1962); Chem. Abstr., <u>58</u>, 5559^g (1968).
- 51. Ambekar, S.Y., Dandeganoker, S.H., Jolad, S.D. and Rajagopal, S., J. Indian Chem. Soc., 40, 1041 (1963).
- 52. Algar, J. and Flynn, J.P., Proc. Roy. Irish Acad., <u>42B</u>, 1 (1934).

- 53. Oyamada, T., J. Chem. Soc. Japan, <u>55</u>, 1256 (1934); Bull. Chem. Soc. Japan, <u>10</u>, 182 (1935).
- 54. Narasimhachari, N., Rajagopalan, D. and Seshadri, T.R., Proc. Indian Acad. Sci., 37A, 705 (1953).
- 55. Geissman, T.A. and Fukushina, D.K., J. Am. Chem. Soc., <u>70</u>, 1686 (1948).
- 56. Narasimhachari, N. and Seshadri, T.R., Proc. Indian Acad. Sci., 30A, 216 (1949).
- 57. Cullen, W.P., Donnelly, D.M.X., Keenan, A.K., Lavin, T.P., Melody, D.P. and Philbin, E.M., J. Chem. Soc., C, 2848 (1971).
- 58. Simpson, T.H. and Whalley, W.B., J. Chem. Soc., 166 (1955).
- 59. Anand, N., Iyer, R.N. and Venkataraman, K., Proc. Indian Acad. Sci., 29A, 203 (1949).
- 60. O'Sullivan, W.I., Brady, B.A. and Philbin, E.M., J. Chem. Soc., D, 1435 (1970).
- 61. Bellino, A. and Venturella, P., Atti. Accad. Soi., Letters
 Arti Palermo, 21, 17 (1962); Chem. Abstr., 59, 552d (1963).
- 62. Seshadri, S. and Trivedi, P.L., J. Org. Chem., <u>25</u>, 841 (1960).
- 63. Cummins, B., Donnelly, D.M.X., Philbin, E.M., Swirski, J., Wheeler, T.S. and Wilson, R.K., Chem. and Ind. (London), 348 (1960).
- 64. Donnelly, D.M.X., Eades, J.F., Philbin, E.M. and Wheeler, T.S., Chem. and Ind. (London), 1453 (1961).

- 65. Cummins, B., Donnelly, D.M.X., Eades, J.F., Fletcher, H., O'Cinneide, F., Philbin, E.M., Swirski, J., Wheeler, T.S. and Wilson, R.K., Tetrahedron, 19, 499 (1963).
- 66. Gromley, T.R. and O'Sullivan, W.I., Tetrahedron, <u>29</u>, 369 (1973).
- 67. Budagyants, M.I., Shakhova, M.K. and Samokhvalov, G.I., Zh. Organ. Khim., <u>5</u>, 1857 (1969); Chem. Λbstr., <u>72</u>, 21600^x (1970).
- 68. Kelkar, Λ S. and Kulkarni, Λ .B., Indian J. Chem., $\underline{11}$, 726 (1973).
- 69. Jerzmanowska, Z. and Podwinski, B., Roczniki Chem., <u>42</u>, 307 (1968).
- 70. Nadkarni, D.R. and Wheeler, T.S., J. Chem. S∞., 1320 (1938).
- 71. Matsuura, S. and Kunii, T., Yakugaku Zasshi, <u>94</u>, 645 (1974); Chem. Abstr., <u>81</u>, 63440^m (1974).
- 72. Hsu, K.K., Shi, J.Y., J. Chem. Soc., Taipei, <u>20</u>, 51 (1973); Chem. Abstr., 78, 159370^c (1973).
- 73. Young, A.N., Dissertation Abstr., Int., 33B, 2536 (1972).
- 74. Matsuura, S., Kunii, T. and Matsuura, Λ., Chem. Pharm.
 Bull., 21, 2757 (1973); Chem. Abstr., 80, 59824^b (1974).
- 75. Chem, F-C., Veng, T., Chen, C.Y. and Chang, P.W., J. Chin. Chem. Soc. (Taipei), <u>17</u>, 251 (1970); Chem. Abstr., <u>74</u>, 87765^c (1971).
- 76. Mahal, H.S. and Venkataraman, K., J. Chem. Soc., 569 (1936).
- 77. Chakravarti, D. and Dutta, J., J. Indian Chem. Soc., <u>16</u>, 639 (1939).

- 78. Joshi, K.C. and Jauhar, A.K., Indian J. Chem., 1, 477 (1963).
- 79. Grishko, L.G., Grabovskaya, V.V., Marchuk, L.A. and Khilya, V.P., Dopov. Akad. Nauk Ukr. RSR, Ser. B, Geol., Khim. Biol. Nauki (5), 426 (1978); Chem. Abstr., <u>89</u>, 108956^t (1978).
- 80. Jain, A.C. and Khazanchi, R., Indian J. Chem., <u>16B</u>, 1125 (1978).
- 81. Ahmad, S., Wagner, H. and Razaq, S., Tetrahedron, <u>34</u>, 1593 (1978).
- 82. Massicot, J., Compt. Rend., <u>240</u>, 94 (1955).
- 83. Bose, P.K., Chakrabarti, P. and Sanyal, A.K., J. Indian Chem. Soc., <u>48</u>, 1163 (1971).
- 84. Kasahare, A., Izumi, T., Ooshima, M., Bull. Chem. Soc. Japan, 47, 2526 (1974).
- 85. Jain, A.C., Lal, P. and Seshadri, T.R., Indian J. Chem., 7, 305 (1969).
- 86. Farkas, L. and Wolfner, A., Magyar Ke'm. Folyoirat, <u>81</u>, 357 (1975); Chem. Abstr., <u>83</u>, 178725⁸ (1975).
- 87. Farkas, L. and Wolfner, A., Flavonoids Bioflavonoids, Proc. Hung. Bioflavonoids Symp., 5th, pp. 193-6 (1977). Edited: Farkas, L., Gabor, M. and Kallay, F., Elsevier, Amsterdam, Netherlands.
- 88. Dean, F.M., Patampongse, C. and Podimuang, V., J. Chem. Soc. Perkin Trans., 1, 583 (1974).

- 89. Wurm, G., Arch. Pharm. (Weinheim), 306, 299 (1973); Chem. Abstr., 79, 66126^h (1973).
- 90. Bhardwaj, D.K., Jain, S.C. and Sharma, G.C., Indian J. Chem., <u>15B</u>, 860 (1977).
- 91. Weber, F.G. and Westphal, G., Pharmazie, <u>30</u>, 283 (1975); Chem. Abstr., <u>83</u>, 96951^y (1975).

CHAPTER - 6

BIOCHEMICAL CYCLISATION AND DEGRADATION OF CHALCONES

Formation of Flavanones
Benzalcoumaranone
Flavonol and Aurone
Flavonol and Aurone
Anthocyanin and Other Flavonoids
Degradation of Chalcones
References

Formation of Flavanones:

The inter-conversion of chalcone and flavanone, with phloroglucinol type of substitution, has been accomplished at pH = 7, by the aid of enzyme isolated from the peel of Citrus aurantium. Other sources of the enzyme are the peels of C. natsudaidai, C. junos, C. nobilis, C. pseudoparadisi and Poncirus trifoliata.

2',4,4'-Trihydroxychalcone has been successfully isomerized² to the optically active 4',7-dihydroxy-flavanone, by the mediation of the isomerase isolated from soyabean seedling:

However, the chalcone-flavanone isomerase isolated either from the young leaves of <u>Datisca cannabina</u> or from three different seedlings, viz., <u>phaseolus aureus</u>, <u>Cicer arietinum</u> and <u>Petroselinum hortense</u> has failed in its action on chalcone glucoside, including those having a resorcinol type of substitution in ring A. It is interesting to note that the chalcone isomerase isolated either from the flowers of Apeldoorn tulips or <u>Lilium candidum</u> is active against 2',4,4',6'-tetrahydroxychalcone, but is ineffective against 2',4,4'-trihydroxychalcone.

Several studies have been reported about the chalcone-flavanone isomerase activity in plants. The chalcone-flavanone isomerase obtained from soyabean seeds has been purified. The kinetics of the isomerisation reaction, viz., isoliquiritigenin to liquiritigenin, conducted under the influence of the aforesaid enzyme has been examined. 10

Formation of Benzal-coumaranone:

Enzyme catalysed transformation, at pH 5-6, of hydroxy-chalcone glycoside to hydroxy benzalcoumaranone glycoside has been reported. The required enzyme is obtained by alcoholime extraction of the macerated rays of Coreopsis lanceolata.

Formation of Flavonol and Aurone:

Under aerobic conditions and in the presence of trace quantity of hydrogen peroxide, isoliquiritigenin (2',4,4'-

trihydroxychalcone) undergoes catalyzed oxidation by Horse-raddish peroxidase 12 to yield 4',7-dihydroxyflavonol and 4',6-dihydroxyaurone. A similar reaction occurs under the influence of cell-free extracts of hypocotys obtained from Phaseolus vulgaris.

Formation of Anthocyanin and Other Flavonoids:

It has been established that 2',3,4,4',6'-penta-hydroxychalcone-4'-glucoside serves as a precursor in the synthesis of anthocyanin^{13,14} and other flavonoids¹⁵ in <u>Petunia hybrida</u>.

On the basis of radioactive labelled feeding experiments it has been shown 16,17 that chalcones, rather than flavanones, are the intermediate precursors in the synthesis of other flavanoids. 2',4,4'-Trihydroxychalcone is reported 18 to be a precursor in the biosynthesis of coumestrol in the seedlings of Phaseolus aureus. Further, it has been shown 19 that there is maximum incorporation of the aforesaid chalcone into amorphigenin by germinating Amorpha frutucosa seeds.

Degradation of Chalcones:

A few cases of degradation by chalcones brought about by plant cell suspension outtures have been reported. 20,21 For example, 2',4,4',6'-tetrahydroxychalcone-2'- β -D-glucoside 21 undergoes degradation by callus suspension cultures of Pisum

sativum L., into para-hydroxybenzoic acid and 3-(hydroxyphenyl)-prop-2-enoic acid.

The chalcone content in the peel of pine apple fruit is reported 22 to decrease with maturity.

References

- 1. Shimokoriyama, M., J. Am. Chem. Soc., 79, 4199 (1957).
- 2. Wong, E. and Moustafa, E., Tetrahedron Letters, 3021 (1966).
- 3. Grambow, H.J. and Grisebach, H., Phytochem., 10, 789 (1971).
- 4. Hahlbrock, K., Wong, E., Schill, L. and Grisebach, H., Phytochem., 9, 949 (1970).
- 5. Wiermann, R., Planta, 102, 55 (1972).
- 6. Forkmann, G. and Kuhn, B., Planta, 144, 189 (1979).
- 7. Boland, M.J. and Wong, E., Bioorg. Chem., 8, 1 (1979).
- 8. Kuhn, B., Forkmann, G. and Seyffert, W., Planta, <u>138</u>, 199 (1978).
- 9. Weissenboeck, G. and Sachs, G., Planta, 137, 49 (1977).
- 10. Boland, M.J. and Wong, E., Eur. J. Biol., 50, 383 (1975).
- 11. Shimokoriyama, M. and Hattori, S., J. Am. Chem. Soc., <u>75</u>, 2277 (1953).
- 12. Rathmal, W.G. and Bendal, D.S., Biochem. J., <u>127</u>, 125 (1972).
- 13. Endress, R., Phytochem., 13, 421 (1974).
- 14. Endress, R., Phytochem., 13, 599 (1974).

- 15. Endress, R., Z. Pflanzenphysiol., <u>67</u>, 188 (1972); Chem. Abstr., <u>77</u>, 58895^b (1972).
- 16. Wong, E., Phytochem., 7, 1751 (1968).
- 17. Wong, E. and Grisebach, H., Phytochem., 8, 1419 (1969).
- 18. Dewick, P.M., Barz, W. and Grisebach, H., Phytochem., 9, 775 (1970).
- 19. Crombie, L., Dewick, P.M. and Whiting, D.A., J. Chem. Soc., D, 1183 (1971).
- 20. Berlin, J., Kiss, P., Mueller-Enoch, D., Gierse, D., Barz, W. and Janistyn, B., Z. Naturforsch., 290, 374 (1974).
- 21. Janistyn, B., Barz, W. and Pohl, R., Z. Naturforsch., <u>26B</u>, 973 (1971).
- 22. Lodh, S.B., Divakar, N.G., Chadha, K.L., Melanta, K.R. and Selvaraj, Y., Indian J. Hort., 30, 381 (1973).

CHAPTER - 7

MISCELLANEOUS REACTIONS OF CHALCONES

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With Caustic Alkali 1:

The olefinic bond in the chalcone molecule undergoes cleavage when refluxed with concentrated alkali (i.e., 0.3 molar)² giving rise to acetophenone and benzaldehyde. Kinetic study³ of the above reaction has been carried out, and mechanism^{2,4} have

put forward to explain the formation of these products

$$\phi - CH = CH - C - \phi + OH^{\Theta} \qquad \phi - CH - CH = C - \phi$$

$$\phi - CH - CH = C - \phi \qquad \phi - CH - CH_2 - C - \phi$$

$$\phi - CH - CH_2 - C - \phi \qquad \phi - CH - CH_2 - C - \phi$$

$$\phi - CH - CH_2 - C - \phi = \phi - C - H + \phi - COCH_2^{\Theta}$$

$$\phi - COCH_2 + H_2O = \phi - COCH_3 + OH^{\Theta}$$

hydroxide ions. 3,5

In case of some chalcones, higher molecular weight compounds have been isolated. Thus anisal- $\underline{\text{bis}}(3,4\text{-dimethoxy-acetophenone})^6$ is produced by the reaction of caustic alkali with 3',4,4'-trimethoxychalcone.

With Sulphuric Acid:

Chalcones usually show halochromic effects when wetted with concentrated sulphuric acid (vide halochromism). Some chalcones remain unchanged on this treatment, while others are susceptible to sulphonation, 7 in ring B. Thus 4-methoxy chalcone and 4,4'-dimethoxychalcone are converted, in the above reaction, to their corresponding sulphonic acid derivatives, while 4'-methoxychalcone remains unaffected.

The following reactions take place when chalcone is reacted with sulphuric acid. The first step is the protonation of the carbonyl oxygen followed by the slow formation of monosulphonic acid acid.

$$\phi - CH = CHCO \phi + H_2SO_4 = \phi CH = CH - C - \phi + HSO_4$$

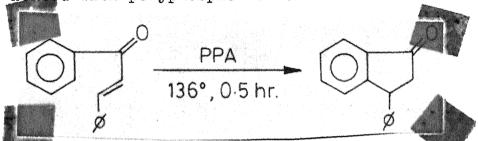
$$\theta = 0H$$

$$\frac{H_2SO_4}{\Theta} - HO_3S - C_6H_4CH = CH - C - \phi + HSO_4 + H_3O_4$$

$$\theta = 0H$$

With Polyphosphoric Acid (PPA):

Chalcone is transformed into 3-phenylindan-1-one (50%) when it is heated with polyphosphoric acid 9 :



Two side reactions, one leading to the formation of dihydrochalcone and the other to an aromatic acid (formed by <arbonyl cleavage) have been observed.⁹

With Phenylacetic Acid:

Chalcone reacts with disodiophenyl acetic acid (prepared by the interaction of the acid with two equivalents of sodium amide in liquid ammonia) to give the corresponding keto acid in excellent yield:

$$\emptyset \text{ CH COONa} \xrightarrow{\text{i } \emptyset \text{ CH=CHCO}\emptyset} \emptyset - \text{CH} - \text{CH}_2 - \text{C} = 0$$

$$0 \text{ CH COONa} \xrightarrow{\text{ii } H_2\text{O, HCl}} \emptyset - \text{CH} - \text{COOH}$$

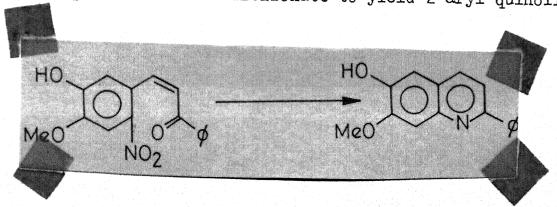
With Sodium Bisulphite:

2'-Hydroxychalcone is reported 1 to react (at 135') with bisulphite to yield 21% of 2 (o-hydroxybenzoyl)-1-phenylethane sulphonic acid. 4'-Hydroxy-2'-methoxychalcone and 4'-hydroxy-3,3',4-trimethoxychalcone react with sodium bisulphite in an analogous fashion.

With Alkali Sulphide:

Chalcone hydrosulphide, 12 ØCH = CH-Ø-C(OH)-SH is produced when chalcone, in alcoholic potassium hydroxide is saturated with hydrogen sulphide. Dibenzalacetophenone disulphide, 12 however, results when chalcone and NaSH are treated in an alcoholic solution. $\underline{\text{Trans}}$ - \angle -bromomethylchalcone reacts with sodium hydrogen sulphide to yield the following products 13 :

6-Nitrochalcones undergo reductive cyclisation 14 with ammonium sulphide or sodium dithionate to yield 2-aryl quinolines:



With Anhydrous Aluminium Chloride:

Chalcone undergoes cyclisation with fused AlCl₃-NaCl to yield the 3-phenyl-1-indanone (60%). 15

Under Friedel-Crafts conditions, chalcones in general yield different products depending upon several factors, 16,17 for example, time and temperature of reaction and steric influences. Chalcone on treatment with anhydrous AlCl3 in benzene yields $\beta \beta$ '-diphenyl propiophenone (90%) 17 together with small amounts of 3-phenyl hydrindone 17 and cis-chalcone. 18 While on the other hand \prec -methyl and \prec -phenyl chalcones, under similar conditions yield the corresponding hydrindones. In these two cases apparently the steric effects 17 are responsible for the formation of hydrindone in preference to the addition product. There are also reports about the preparation of $\beta\beta$ '-disubstituted propiophenones 19 and/or of substituted hydrindones 20 based on the aforesaid reaction. Aluminium chloride is also reported 21 to bring about partial demethylation. Thus 2'-hydroxy-4',6'-dimethoxy chalcone, under the above conditions, yields 2',4'-dihydroxy-6'-methoxychalcone.

Furthermore, chalcone and chlorobenzene react in presence of AlCl₃ to give products as indicated²²: $\phi - C - CH = CH - \phi$ $\frac{5 \text{ hr}}{0} - C - CH_2 - CH$ $\frac{17 \text{ hr}}{0} - C - CH_2 - CH(C_6H_4Cl)_2$ $\frac{17 \text{ hr}}{0} - C - CH_2 - CH(C_6H_4Cl)_2$ $\frac{17 \text{ hr}}{0} - C - CH_2 - CH(C_6H_4Cl)_2$ $\frac{17 \text{ hr}}{0} - C - CH_2 - CH(C_6H_4Cl)_2$

attracted to the $oldsymbol{eta}$ -carbon atom. When the reaction period is

prolonged, then the replacement of the phenyl group by chlorophenyl residue takes place at the β -carbon atom, leading to the formation of II.

With Nitrosoyl Chloride 23:

At room temperature chalcone adds to a molecule of nitrosoyl chloride and a good yield of the adduct is obtained.

With Sodium Amide 24:

2',4,4'-Trimethoxychalcone on treatment with sodium amide in refluxing toluene undergoes molecular cleavage to yield 1-amido- 2(p-methoxyphenyl) ethylene and 1,3-dimethoxybenzene.

With Mercury Salts:

Mercury chloride and mercury bromide are reported 25 to yield addition products with chalcone. \checkmark -Mercuration occurs 26 when chalcone is reacted with mercuric acetate in presence of \underline{t} -butyl hydroperoxide and perchloric acid.

$$\emptyset \text{CH} = \text{CHCO}\emptyset \xrightarrow{\text{t-Butyl peroxy mercuration}}$$
 $\emptyset \text{CH}(0-0 \text{ Bu}^{\text{t}}) \text{ CH}(\text{HgOAc})$

$$- \text{CO}\emptyset \qquad 77\%$$

A parallel pattern of behaviour is exhibited by chalcone in methoxymercuration reaction. The kinetics of methoxymercuration of substituted chalcones has been studied. The following mechanism has been postulated for the above-mentioned reaction:

HH Hg (OAc)₂ Slow
$$\phi$$
 H ϕ HgOAc + ϕ Ac ϕ H ϕ HgOAc + ϕ CH₃OH ϕ H ϕ HgOAc ϕ CH₃OH ϕ CH₃O

With Iron Carbonyl:

The preparation of several iron carbonyl (tri- and tetra-) complexes of ferrocene analogues of chalcone has been described 28 The introduction of the iron carbonyl moiety is reported to interfere with the conjugation in the molecule of ferrocene analogue of chalcone.

Iron carbonyl, Fe₂(CO)₉ reacts with chalcone to yield a complex. The iron-carbonyl chalcone complex reacts with triphenylphosphine 29 in accordance with the reaction:

$$\phi COCH = CH \phi$$

$$\phi COCH = CH \phi$$

$$\psi COCH = CH \phi$$

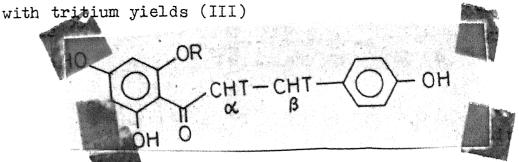
$$\psi COCH = CH \phi$$

$$\psi 3P + \phi 3P + e(CO) 4$$

$$\psi (\phi 3P)_2 + e(CO)_3$$

With Tritium³⁰:

Hydrogenation of 2'-D-glucosyl-4,4',6'-trihydroxychalcone with tritium vields (III)



The incorporation of tritium in the dihydro-compound (III) is reported 30 to be of the order of 60% at the \sim -carbon atom (with respect to the carbonyl group) and 15-20% at the β -carbon atom respectively.

With Heavy Water 31:

The -hydrogen of chalcone does not exchange for deterium
 when it is heated with heavy water-dioxan in the presence of a
 basic catalyst.

With Deuterioethanol:

Chalcone is reported³² to undergo base catalysed deuteration with deuterioethanol, to yield the __ -deuterioketone (42%).

With Benzene and Nitroparaffins:

-substituted chalcone derivatives are reported³³ to undergo
 addition reaction with benzene in the presence of palladium (II)
 acetate.

Chalcones react with nitroparaffins, ^{38,39} e.g., nitromethane, ³⁴⁻³⁷ 1-(and -2) nitropropanes ³⁵ and gem-dinitroalkanes, ⁴⁰ to give Michael type addition compounds, generally in excellent yields. ³⁸ This reaction has been accomplished under the influence of basic catalysts, namely alcoholic ammonia, ³⁴ calcium hydride ³⁵ in methanol or pyridine. ⁴⁰

The primary addition product of chalcone and nitromethane, ³⁶ for example, is 4-nitro-1,3-diphenylbutan-1-one (IV), further reaction yielding the <u>bis</u> adduct (V)

PhCH -
$$CH_2COPh$$

CH₂ - NO_2

Ph - $CH - CH_2COPh$

CHNO₂

Ph - $CH - CH_2COPh$

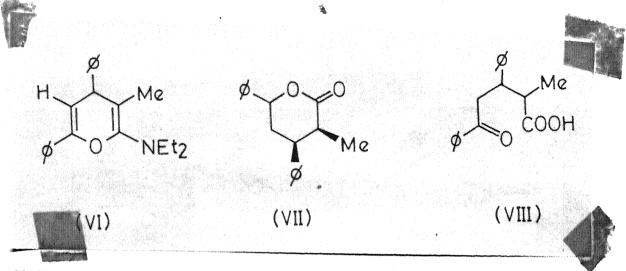
(IV)

With Diazomethane:

Chalcone reacts additively with diazomethane to yield two isomeric pyrazolines, 41 which upon heating pass into cyclopropane derivative. 42 Homologation of chalcone, however, occurs, 43 without significant pyrazoline formation, if the reaction with diazomethane is performed in the presence of fluoroboric acid.

With 1,1-Diethylaminoprop-1-yne:

Chalcone is reported⁴⁴ to react with 1,1-diethylaminoprop-1-yne to yield a pyran derivative (VI) which on hydrolysis gives the lactone (VII) and keto acid (VIII).



With Alcohols:

(a) Chalcones react with nitroethyl- and nitro-isopropyl alcohols in liquid ammonia, according to the scheme 45:

$$\emptyset - COCH = CH\emptyset - \begin{cases} NO_2CH_2CH_2OH \\ (45\%) \end{cases}$$

$$\emptyset - COCH_2 \left[CH(NO_2) CH_2OH \right] CH\emptyset$$

$$\emptyset - COCH_2 - CH - \left[MeCH(OH)CHNO_2 \right]$$

$$(23\%)$$

(b) The selective hydrogenation of chalcone has been achieved 46 by using ethylene glycol in the presence of a catalyst, $\mathrm{RuCl}_2.\mathrm{PØ}_3.$ The yield of \checkmark , β -saturated ketones 46 thus range between 77 to 99%. As an extension of this reaction, chalcone has been used as a solvent-hydrogen acceptor 47 in the presence of $\mathrm{RuCl}_2.\mathrm{PØ}_3$ for effecting dehydrogenation of \checkmark -ethylenic alcohols and glycols.

With Thiols 48,49:

to re

Excellent yields of keto sulphides (IX) are reported 48 to be obtained when substituted chalcone and the hydrochlorides of 2-diethylaminoethyl and 3-diethylaminopropyl mercaptans are allowed

$$\begin{array}{c} R \\ \bigcirc \bigcirc \bigcirc - CH - CH_2CO - \bigcirc \bigcirc \bigcirc \bigcirc \\ SR'' \\ \hline \\ (IX) \\ R'' = Et_2 NCH_2 CH_2 - : \\ Et_2 NCH_2 CH_2 CH_2 - \end{array}$$

Pentanethiol, benzene thiol and toluene thiol likewise react with ferrocene analogue of chalcone to give their corresponding adducts. 50

2-Aminoethanethiol,⁵¹ however, reacts with chalcone to yield either a mono-adduct ((X) and (XI)) or the <u>bis</u> compound (vide infra) depending upon the molar proportion of the reactants used:

$$\emptyset$$
 CO CH₂ CH \emptyset S (CH₂)₂ NH₂ (X)
 \emptyset CO CH₂ CH \emptyset NH (CH₂)₂ SH (XI)
 \emptyset CO CH₂CH \emptyset S (CH₂)₂ NH CH \emptyset CH₂CO \emptyset

With Selenols:

Arylselenols add readily to chalcone in ethanol, in the absence of a catalyst. The yield of the product, viz., ketoselenides 52 vary from 44 to 80%.

With 3,5-Dimethoxyphenol⁵³:

Substituted chalcone is reported 53 to undergo β -coupling with 3,5-dimethoxyphenol, in the presence of alkaline hydrogen peroxide, to yield the two structural isomers of 3,3-diaryl-2-

S-Lactones⁵⁵ are obtained from chalcones by their interaction with diphenylketene quinoline, followed by an oxidative step. The preparation of α , α -diphenyl- β -methoxyphenyl- Υ -benzoyl butyric lactone (XII) is illustrated⁵⁵:

$$MeO-C_6H_4CH = CHCO \phi + \phi_2 C = CO.C_9H_7N - ~140^\circ$$

$$MeO-C_6H_4CH=CHC\phi=C\phi_2 \xrightarrow{Oxidn.} MeO-H_4C_6 \xrightarrow{\phi} 0$$

Chalcone is reported 56 to react with one equivalent of kete acetal to yield 1,1-diethyl-2-benzoyl-3-phenylcyclo-butane (XIII) which may be hydrolysed to 3- β -phenyl- γ -benzoyl butyric acid (XIV).

(XIII)

(XIV)

The Michael type reaction of chalcone with o-silylate. ketene furnishes the corresponding $\boldsymbol{\xi}$ -keto esters 57 in good The following is an illustrative example:

With Benzoyl Chloride:

Pyrylium salts⁵⁸ are formed when β -methyl chalcones, in acetic acid, are reacted with benzoyl chloride in the presence of a Lewis acid. One of the possible mechanisms suggested⁵⁸ for the

With Benzyl-p-tolyl Sulphone:

In the presence of sodium ethoxide, chalcone is reported to condense with benzyl-p-tolyl sulphone to yield a product 59 (XV, $\sim 15\%$) which exists in two isomeric forms:

(IIVX)

With Sulfenyl Compounds:

Chalcones react with phenyl sulfenyl chloride 60 in acetic acid medium to furnish an adduct (XVI) or thioaurones (XVII

CI

$$S\phi$$

 O
 $(XVII)$
 $R = Me, CI$
 $R = O - OH; O - CI; O - MeO; O - M$

1-(Phenylsulfinyl)-2,4-diphenyl-3-buten-2-ol⁶¹ is preparable by the interaction of chalcone with $QS(0)CH_3$ in the presence of sodium amide in liquid ammonia.

With Dimethyl Sulphonium and Sulphoxonium Methylides:

Dimethyl sulphonium methylide is reported 62 to react with chalcone to yield the corresponding oxirane by the selective addition of methylene to carbonyl group:

on the other hand, trans chalcone reacts with dimethyl sulphoxium methylide (DMSOM) leading to the formation of trans 1-phenyl-2benzoylcyclopropane. 62 2-Methoxychalcone, on prolonged treatment

with DMSOM, however, yields (XVIII) which cyclises to pyran derivative 64 (XIX) in the presence of acid. Thus:

$$\phi$$
-coch=chc₆H₄OMe-2 DMSOM ϕ -co-ch-ch-c₆H₄OMe-

$$\begin{array}{c|c}
\hline
DMSOM & \phi - C - CH - CH - C_{6}H_{4}OMe - 2 \\
\hline
O - CH_{2} - CH_{2}
\end{array}$$

HOCH

2

CHCH2CH(OH)C6H4OMe-2

$$\phi$$

(XVIII)

(XIX)

With Nitrone:

C, N-Diphenylnitrone and N-methyl-C-phenylnitrone are reported to undergo 1,3-dipolar cyclo-addition with p-substituted chalcone, to yield the corresponding isoxazolidine ring system.

With Nitrogen Heterocycles:

Chalcones have been reacted with several nitrogen heterocycles, for example, piperidine, ⁶⁷ morpholine, ⁶⁷ N-bromo-morpholine, ⁶⁸ piperizine, ⁶⁹ indoles ^{70,71} and azoles ⁷² to yield the corresponding

Michael adducts. The following serve as examples
67
 $CH = CH - C$
 $CH = CH - CO$
 $CH = CH - CH$
 $CH = CH - CH$
 $CH = CH$
 CH

pyridyl or morpholinyl residue). The addition compounds are unstable and break up into its constituents in hot water.

A Michael adduct is formed by the interaction of chalcone with 3,5-dimethyl-4-nitroisoxazole. The adduct on reductive cyclisation is reported to yield 73 the corresponding azepine derivative.

With Hydrazoic Acid:

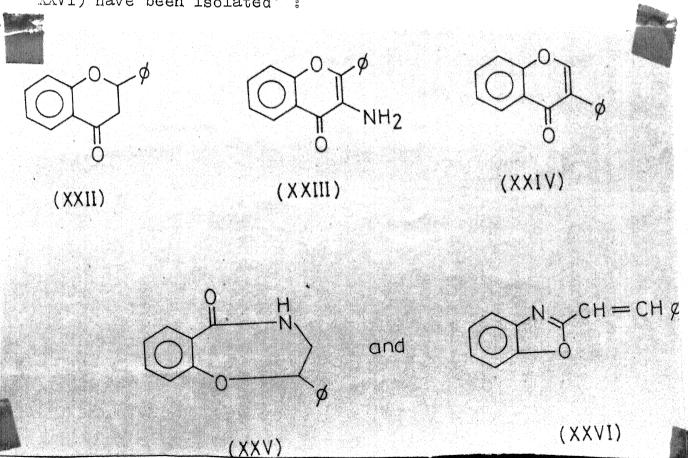
The Schmidt reaction on highly hindered <u>cis</u>-chalcone is reported 74,75 to yield quinoline derivatives.

A
B
N3H, H2SO4
$$\phi$$

(XXX) $A = B = \phi$;
(XXI) $A = B = Br$

The kinetics of this reaction has been studied. 76,77

The reaction of hydrazoic acid with 2'-hydroxychalcone has been carried out. 78 The following heterocyclic compounds (XXII-XXVI) have been isolated 78:



With Hydroxylamine:

Chalcone and substituted chalcones react with hydroxylamine hydrochloride to form the corresponding unsaturated ketoximes. The ketoximes are reported 79,80,90-93 to undergo a variety of reactions, viz., cyclisations, catalytic hydrogenation, Beckmann rearrangement etc.

3,5-Diphenylisoxazoline is formed ^{79,80} when chalcone is allowed to react with hydroxylamine in an alkaline medium. It is believed ⁸¹ that chalcone <u>syn</u>-oxime is formed in the reaction, which undergoes cyclisation to the corresponding isoxazoline derivative. Chalcones carrying substituents in the 4- and 4'-positions react, under acid conditions, with hydroxylamine hydrochloride to yield isoxazolines and chalcone <u>syn</u>-oximes. On the other hand isoxazolines along with other products are formed under alkaline conditions. ^{84,85} Isoxazolines (XXVII) derived from naphthalene analogues of chalcone have been secured ⁸⁶ by their reaction, at a higher temperature, with hydroxylamine in presence of pyridine.

In some cases the formation of isoxazole^{82,88,89} and dihydroisoxazole⁸⁷ have been reported. The mechanism of isoxazole formation is reported⁸⁸ to take place by 1,2-addition.

With Hydrazine:

Hydrazones⁹⁴ or pyrazolines⁹⁵ are formed by the reaction of chalcone with hydrazine. 4,5-hydro-1H-pyrazoles⁸⁷ are, however, produced from 2-hydroxychalcones in the above reaction.

With Phenylhydrazine:

R'= H; R = OH

Chalcone (The phenylhydrazine (196,94,96,97) in acetic acid medium to yield the corresponding phenylhydrazones (196,98) (XXIX). The phenylhydrazones can be transformed into 1,3,5-triphenylpyrazolines (XXX) by refluxing these with acetic acid. Some chalcone phenylhydrazones (XXVIII b) are labile and are readily converted to pyrazolines, (196) even at room temperature. If a mixture of chalcone and phenylhydrazine are reacted at higher temperature, the intermediate hydrazone undergoes cyclisation to

With 2,4-Dinitrophenylhydrazine 94,99-103 (DNPH):

The chief advantage of DNPH over phenylhydrazine as a reagent for characterization of chalcones is the ease of separation of the crystalline hydrazones with characteristic sharp melting points. The preparation of some substituted chalcone 2,4-dinitrophenyl hydrazones are reported 99-101 in the literature.

The reactivity of carbonyl group is chalcones, in respect of their formation of 2,4-dinitrophenylhydrazones has been examined. 102,103 The close proximity of the hydroxyl group hinders the reactivity of the carbonyl group on account of chelate formation. Substituents located in the para position with respect to the carbonyl function alter, depending upon their inductive effects, 102,103 the rate of 2,4-dinitrophenylhydrazone formation.

With Hydrazine Derivatives:

Several other hydrazine derivatives, 104-107 viz., 1-menthy-drazide 104; 3,5-dinitro-4-tolyl hydrazine, 105 phenyl sulphonyl-hydrazide 106 and tosylhydrazine 107 have been used for the characterization of chalcones. One of these derivatives, viz., tosylhydrazone, has an important synthetic application and is used as a starting material for the preparation of substituted cyclopropenes. 107

With Disubstituted Phosphine Oxide:

Addition across the olefinic linkage occurs when chalcone is reacted with disubstituted phosphine oxide, 108 under basic conditions, thus:

$$(\emptyset CH_2)_2 P(0)H + \emptyset CH = CHCO\emptyset$$

$$\frac{EtOH-EtONa}{(\emptyset CH_2)_2 P(0)-CH-CH_2-CO\emptyset}$$

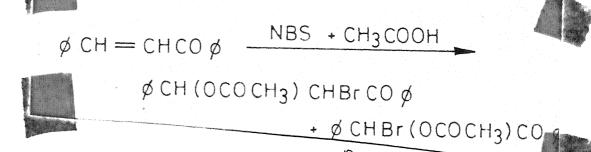
$$\emptyset$$

$$(92\%)$$

With N-bromosuccinimide (NBS):

 β -phenylchalcone on treatment with N-bromosuccinimide, gives the α -bromo derivative (XXXI). The reaction involves a radical mechanism and is initiated by a trace of Br_2 formed by the decomposition of N-bromosuccinimide.

Bromoacetoxylation of several chalcones are reported 110 and is capited out by the reaction of chalcone with NBS in acetic acid.



Apparently \angle -bromo- β -acetoxy-, and β -bromo- \angle -acetoxy somer are produced in the reaction, the relative proportion of which varies from chalcone to chalcone.

With Bromine Azide 111:

Bromine azide adds very slowly to chalcone in methylene chloride-nitromethane, in the following way:

The reaction can, however, be made to go at a reasonable rate by incorporating an acid catalyst.

Pyrolysis:

Pyrolysis of chalcone at about 700° in the presence of aluminium bronze powder, is reported 112 to yield stilbene and 1,4-(m-biphenylyl)-benzene.

Autocondensation:

Chalcones are reported 113 to undergo autocondensation in the presence of ethyl formate-perchloric acid to yield 2,4,6-triaryl pyrylium salt in a poor yield (18-48%).

pyrylium salt in a poor yield (18-48%).

$$R = R' = Phenyl$$

$$= 3,4 - (MeO)_2 C_6 H_3;$$

$$= 3,4 - (CH_2O_2)C_6 H_3.$$

Copolymerization of Chalcone/Chalcones Analogues

With Styrene:

Substituted chalcone and styrene 114-116 form a copolymer (85% conversion 115) involving the use of a free radical initiator. The product is described as hard, clear solid polymer, with a heat distortion point of 97° (cf. polystyrene, 78°). A resinous solid, however, is obtained by the ionic interpolymerization of chalcone and styrene with boron trifuluoride 119 (at -80°) in methylene chloride.

With Butadiene:

1,3-Butadiene 115 monomer copolymerizes readily with \checkmark , β - unsaturated carbonyl compounds in presence of benzoyl peroxide. The carbonyl compounds studied include, chalcone, 115 2-chlorochalcone, 118 furfural-acetophenone, 118 furfural-p-chloroacetophenone 118 and some pyridine analogues 119 of chalcone, viz., 2-(3- and 4-) pyridal acetophenones, 2-pyridal-4-chloroacetophenone and 2-pyridal-2'-acetyl-acetophenone. It may, however, be noted that 2-pyridal-4'-amino acetophenone 119 fails to form a copolymer with 1,3-butadiene.

With Acrylonitrile and Isoprene 120:

Copolymers derived from acrylonitrile (and isoprene) and pyridine analogues of chalcones are described 120 in literature.

Synthesis of m-polyphenyls 121:

Chalcone serves as a starting material for the synthesis of m-polyphenyl system. The following sequence of reaction steps 121 are necessary in bringing about the required transformation, taking the synthesis of m-terphenyl as an illustrative example:

CH=CH-C
$$\times$$
 CH3COCH2COOEt \times NaOEt \times (X = H, Br)

Synthesis of 1,3-Diphenylglycerol 122:

Starting with chalcone and taking it through a series of chemical transformations, the two isomers, viz., <u>erythro-erythro</u> and <u>erythro-threo</u>, of 1,3-diphenylglycerol have been isolated ¹²² and identified.

Synthesis of Aryl Benzyl Ethanolamines:

The title compounds have been obtained 123 by the following series of reactions. Thus,

References

- 1. Shriner, R.L. and Kurosaws, T., J. Am. Chem. Soc., <u>52</u>, 2538 (1930).
- 2. Carsky, P., Zuman, P. and Horak, V., Coll. Czech. Chem. Commun., 30, 4316 (1965).
- 3. Walker, E.A. and Young, J.R., J. Chem. Soc., 2045 (1957).
- 4. Van Senden, K.G. and Koningsberger, C., Tetrahedron, <u>22</u>, 1301 (1966).
- 5. DeBlic, A. and Maroni, P., Bull. Soc. Chim. France (3-4), 512 (1975).

- 6. Wacek, A.V. and David, E., Chem. Ber., 70B, 190 (1937).
- 7. Pfeiffer, P. and Negreanu, P.A., Chem. Ber., <u>50</u>, 1465 (1917).
- 8. Gillespie, R.J. and Leisten, J.A., J. Chem. Soc., 1 (1954).
- 9. Allen, J.M., Johnston, K.M., Jones, J.F. and Shotter, R.G., Tetrahedron, 33, 2083 (1977).
- 10. Hauser, C.R. and Tetenbaum, M.T., J. Org. Chem., <u>23</u>, 1146 (1958).
- 11. Kratzl, K. and Daubner, H., Chem. Ber., 77B, 519 (1944).
- 12. Fromm, E. and Hubert, E., Ann., 394, 290.
- 13. Padwa, A. and Gruber., Chem. Commun., (1), 5 (1969).
- 14. Rao, K.V., J. Heterocyclic Chem., 12, 725 (1975).
- 15. Bruce, D.B., Sorrie, A.J.S. and Thomson, R.H., J. Chem. Soc., 2403 (1953).
- 16. Sammour, A. and Elkasaby, M., U.A.R. J. Chem., <u>13</u>, 409 (1971); Chem. Abstr., <u>77</u>, 101261^f (1972).
- 17. Koelsch, C.F., J. Org. Chem., 26, 2590 (1961).
- 18. Davey, W. and Guilt, J.R., J. Chem. Soc., 1017 (1957).
- 19. Joshi, K.C. and Jauhar, A.K., J. Indian Chem. Soc., <u>43</u>, 368 (1966).
- 20. Takatori, M. and Kanomate, K., Bull. Chem. Soc. (Japan), 48, 3411 (1975).
- 21. Narasimhachari, N. and Seshadri, T.R., Proc. Indian Acad. Sci., 29A, 265 (1949).
- 22. Dippy, J.F.J. and Palluel, A.L.L., J. Chem. Soc., 1415 (1951).

- 23. Perrot, R., Compt. Rend., 203, 329 (1936).
- 24. Romano, C., Ann. Chim. (Rome), <u>60</u>, 405 (1970); Chem. Abstr., 73, 87603^C (1970).
- 25. Vorlander, D. and Eichwald, E., Chem. Ber., 56B, 1150 (1923).
- 26. Bloodworth, A.J. and Bruce, R.J., J. Chem. Soc. C, 1453 (1971).
- 27. Patraik, A.K., Nayak, P.L. and Rout, M.K., Indian J. Chem., 8, 722 (1970).
- 28. Nesmeyanov, A.N., Shul'pin, G.B., Rybin, L.V., Gubenko, N.T., Rybinskaya, M.I' and Petrovsky, P.V. and Robas, V.I., Zh. Obshch. Khim., 44, 2032 (1974).
- 29. Nesmeyanov, A.N., Rybin, L.V., Gubenko, N.T., Petrovsky, P.V. and Rybinskaya, M.I., Zh. Obshch. Khim., 42, 2473 (1972).
- 30. Cabak, J. and Veres, K., Radiochem. Radioanal. Letters, (12), 6, 331 (1972).
- 31. Kursanov, D.N. and Parnes, Z.N., Doklady Akad. Nauk SSSR, 91, 1125 (1953); Chem. Abstr., 48, 10549^c (1954).
- 32. Zinn, M.F., Harris, T.M., Hill, D.G. and Hauser, C.R., J. Am. Chem. Soc., 85, 71 (1963)
- 33. Yamamura, K., J. Org. Chem., <u>43</u>, 724 (1978).
- 34. Worral, D.E. and Bradway, C.J., J. Am. Chem. Soc., <u>58</u>, 1607 (1936).
- 35. Fishman, N. and Zuffanti, S., J. Am. Chem. Soc., <u>73</u>, 4466 (1951).
- 36. Davey, W. and Tivey, D.J., J. Chem. Soc., 2276 (1958)

- 37. Colonna, S., Hiemstra, H. and Wynberg, H., Chem. Comm., (6), 238 (1978).
- 38. Profft, E. and Wolf, E., J. Prakt. Chem., 19, 192 (1963).
- 39. Seter, J., Israel J. Chem., <u>4</u>, 1 (1966); Chem. Abstr., <u>66</u>, 2294^r (1967).
- 40. Solomonovici, A., Israel J. Technol., <u>7</u>, 441 (1969); Chem. Abstr., 72, 89961^W (1970).
- 41. Smith, L.I. and Pings, W.B., J. Org. Chem., 2, 23 (1937).
- 42. Ghate, C.G., Kaushal, K. and Deshpande, S.S., J. Indian Chem. Soc., 27, 633 (1950).
- 43. Johnson, W.S. and Birkeland, S.P., Tetrahedron Letters (5), 1 (1960).
- 44. Myers, P.L. and Lewis, J.W., J. Heterocyl. Chem., <u>10</u>, 165 (1973).
- 45. Rumyantseva, K.S., Rumyantsev, N.P., Chekmaeva, G.E. and Kirlyanova, R.P., Uch. Zap. Mord. Univ. No. 81, 75 (1971); Chem. Abstr., 78, 57948⁶ (1973).
- 46. Sasson, Y., Cohen, M. and Blume, J., Synthesis, $\underline{6}$, 359 (1973).
- 47. Dedieu, M. and Pascal, Y.L., C. R. Acad. Sci., Ser. C., <u>278</u>, 1425 (1974); Chem. Abstr., <u>82</u>, 42653^p (1975).
- 48. Gilman, H., Fullhart, L. and Cason, L.F., J. Org. Chem., 21, 826 (1956).
- 49. Davey, W.A. and Guilt, J.R., J. Chem. Soc., 1015 (1957).
- 50. Omote, Y., Komatsu, T., Kobayashi, R. and Sugiyama, N., Nippon Kagaku Kaishi (4), 780 (1972); Chem. Abstr., 77, 33637^{f} (1972).

- 51. Hankovszky, O.H., Hideg, K. and Llyod, D., J. Chem. Soc. Perkin. Trans., 1, 1619 (1974).
- 52. Gilman, H. and Cason, L.F., J. Am. Chem. Soc., <u>73</u>, 1074 (1951).
- 53. Ferreira, D. and Roux, D.G., J. Chem. Soc. Perkin. Trans. I, 134 (1977).
- 54. Lévai, A. and Bognar, R., Acta Chim., 92, 415 (1977).
- 55. Staudinger, H. and Karlsruhe, R.E., Ann., 401, 263.
- 56. McElvain, S.M. and Cohen, H., J. Am. Chem. Soc., <u>64</u>, 260 (1942).
- 57. Saigo, K., Osaki, M. and Mukaiyama, T., Chem. Letters (2), 163 (1976).
- 58. Barker, S.A. and Riley, T., J. Chem. Soc. Perkin Trans.

 Part I (6), 809 (1972).
- 59. Connor, R., Flemming, C.L. (Jr.) and Clayton, T., J. Am. Chem. Soc., <u>58</u>, 1386 (1936).
- 60. Ukai, S., Hirose, K. and Kayano, M., Yakugaku Zasshi, <u>95</u>, 299 (1975); Chem. Abstr., <u>83</u>, 43125^a (1975).
- 61. Gautier, J.A., Miocque, M., Moskowitz, H. and Blac-Guenee, J., French Patent 2,031,714 (1970); Chem. Abstr., <u>75</u>, 48691^b (1971).
- 62. Corey, E.J. and Chaykovsky, M., J. Am. Chem. Soc., <u>84</u>, 3782 (1962).
- 63. Claude, A., C. R. Acad. Sci., Paris, Ser. C., 264, 1128

- 64. Donnelly, J.A., Bennett, P., O'Brien, S. and O'Grady, J., Chem. and Ind. (London), 500 (1972).
- 65. Siemiatycki, M.S., Carretto, J. and Malbee, F., Bull. Soc. Chim. France, 125 (1962).
- 66. Iwakura, Y., Uno, K., Kihara, Y., Setsu, M. and Yamamoto, S., Nippon Kagaku Kaishi (8), 1448 (1972); Chem. Abstr., 77, 139864^t (1972).
- 67. Kozlov, N.S. and Kozlov, G.N., Zh. Obshch. Khim., <u>33</u>, 2184 (1963).
- 68. Southwick, P.L. and Walsh, W.L., J. Am. Chem. Soc., <u>77</u>, 405 (1955).
- 69. Stewart, V.E. and Pollard, C.B., J. Am. Chem. Soc., <u>58</u>, 1980 (1936).
- 70. Merchant, J.R., Salagar, S.S. and Chhatriwala, K.M., Current Sci. (India), 35, 123 (1966).
- 71. Merchant, J.R., Chhatriwala, K.M., Salagar, S.S. and Patell, J.R., J. Indian Chem. Soc., 48, 613 (1971).
- 72. Moffat, J., J. Am. Chem. Soc., 77, 2572 (1955).
- 73. Rao, C.J. and Murthy, A.K., Indian J. Chem., 16B, 636 (1978).
- 74. Pratt, R.E., Dissertation Abstr., 27B, 2656 (1967).
- 75. Pratt, R.E., Welstead, W.J. (Jr.) and Lutz, R.E., J. Heterocyclic Chem., 7, 1051 (1970).
- 76. Mirek, J., Bull. Acad. Polon. Sci., Ser. Sci. Chim., <u>10</u>, 421 (1962); Chem. Abstr., <u>59</u>, 6226^g (1963).
- 77. Mirek, J., Zess. Nauk. Uniw. Jagiellon., Pr. Chem. No. 10, 61 (1965); Chem. Abstr., <u>66</u>, 37125^h (1967).

- Misiti, D., Ann. 1st Super. Sanita, <u>9</u> Part 2-3, 174 (1973);

 Chem. Abstr., <u>81</u>, 63599^V (1974).
- 79. Auwers, K.V. and Seyfried, M., Ann., 484, 178 (1930).
- 80. Auwers, K.V. and Muller, H., J. Prakt. Chem., <u>137</u>, 57 (1933).
- 31. Meisenheimer, J. and Campbell, N., Ann., 539, 93 (1939).
- 32. Samula, K., Roczniki Chem., <u>45</u>, 2063 (1971); Chem. Abstr., 76, 153509^S (1972).
- 83. Henrich, F., Ann., 351, 172.
- 84. Unterhalt, B., Pharm. Zentralhalle, <u>107</u>, 356 (1968); Chem. Abstr., <u>69</u>, 99459^r (1968).
- 85. Uterhalt, B., Pharm. Zentralhalle, <u>107</u>, 356 (1968); Chem. Abstr., <u>70</u>, 57351^q (1969).
- 36. Sammour, A.E.A., Tetrahedron, 20, 1067 (1964).
- 87. Jurd, L., Tetrahedron, 31, 2884 (1975).
- 88. Blecker, H.H., Dissertation Abstr., 15, 2407 (1955).
- 39. Shenoi, B.B., Shah, R.C. and Wheeler, T.S., J. Chem. Soc., 247 (1940).
- 90. Merz, K.W., Ber., 63B, 2951 (1930).
- 91. Dornow, A. and Frese, A., Arch. Pharm., <u>285</u>, 463 (1952); Chem. Abstr., 48, 11374^a (1954).
- 92. Ruchkin, V.E., Shvetsova-Shilovskaya, K.D. and Mel'nikov, N.N., Probl. Poluch. Poluprod. Prom. Org. Sin., Akad Nauk SSSR, Otd. Obshch. Tekh. Khim., 66 (1967); Chem. Abstr., 68, 95417^g (1968).

- 93. Lenka, S., Nayak, P.L. and Rout, M.K., J. Inst. Chem. (India)
 42, 162 (1970).
- 94. Kallay, F., Janzso, G., Kem. Kozl., <u>42</u>, 213 (1974); Chem. Abstr., 83, 9701^a (1975).
- 95. Sammour, A., Selim, M.I.B. and Sayed, G.H., U.A.R. J. Chem.

 14, 235 (1971); Chem. Abstr., 77, 139878^a (1972).
- 96. Raiford, L.C. and Peterson, W.J., J. Org. Chem., <u>1</u>, 544 (1937).
- 97. Hanson, G.A., Bull. Soc. Chim. Belges, <u>67</u>, 707 (1958); Chem. Abstr., <u>53</u>, 18007^a (1959).
- 98. Raiford, L.C. and Davis, H.L., J. Am. Chem. Soc., <u>50</u>, 156 (1927).
- 99. Dhar, D.N., J. Indian Chem. Soc., 37, 320 (1960).
- 100. Allen, C.F.H., J. Am. Chem. Soc., 52, 2955 (1930).
- 101. Langlais, M., Buzas, A., Soussan, G. and Freon, P., Compt. Rend., 261, 2920 (1965).
- 102. David, E.R. and Bognar, R., Acta Chim. Acad. Sci. Hung., 84, 335 (1975); Chem. Abstr., 82, 169686^g (1975).
- 103. David, E.R., Szabo, G.B., Korponai, K. and Bognar, R.,

 Magyar Kém. Folyóirat, <u>81</u>, 328 (1975); Chem. Abstr., <u>83</u>,

 177721^a (1975).
- 104. Woodward, R.B., Kohman, T.P. and Harris, G.C., J. Am. Chem. Soc., <u>63</u>, 120 (1941).
- 105. Sah, P.P.T., J. Chinese Chem. Soc., 14, 45 (1946); Chem. Abstr., 43, 6972^e (1949).
- 106. Dornow, A. and Bartsch, W., Ann., 602, 23 (1957).

- 107. Duerr, H., Angew. Chem. Inter. Ed., 6, 1804 (1967).
- 108. Miller, R.C., Bradley, J.S. and Hamilton, L.A., J. Am. Chem. Soc., 78, 5299 (1956).
- 109. Southwick, P.L., Pursglove, L.A. and Numerof, P., J. Am. Chem. Soc., 72, 1600 (1950).
- 110. Iovchev, A., Spasov, S.L., Stefanovskii, Y.N., Stoilov, L. and Gocheva, V., Monatsh. Chem., 100, 51 (1969).
- 111. Hassner, A. and Boerwinkle, F., J. Am. Chem. Soc., <u>90</u>, 216 (1968).
- 112. Dhar, D.N. and Munjal, R.C., Indian J. Chem., <u>12</u>, 1014 (1974).
- 113. Dorofeenko, G.N., Olekhnovich, E.P. and Laukhina, L.I.,
 Zh. Organ. Khim., 7, 1296 (1971); Chem. Abstr., 75, 98392^a
 (1974).
- 114. Chapin, E.C., U.S. Patent 2,496,697 (1950); Chem. Abstr., 44, 4723° (1950).
- 115. Marvel, C.S., McCorkle, J.E., Fukuto, T.R. and Wright, J.C., J. Polymer. Sci., 6, 776 (1951).
- 116. Marvel, C.S. and Wright, J.C., J. Polymer. Sci., <u>8</u>, 495 (1952).
- 117. Coleman, L.E. (Jr.) and Jones, F.B., J. Polymer. Sci., 31, 528 (1958).
- 118. Marvel, C.S., Peterson, W.R., Inskip, H.K., McCorkle, J.E., Taft, W.K. and Labbe, B.G., Ind. Eng. Chem., <u>45</u>, 1532 (1958).

- 119. Marvel, C.S., Coleman, L.E. (Jr.), Scott, G.P., Taft, W.K. and Labbe, B.G., Ind. Eng. Chem., 48, 214 (1956).
- 120. Marvel, C.S., Coleman, L.E. (Jr.) and Scott, G.P., J. Org. Chem., <u>20</u>, 1785 (1955).
- 121. Sunshine, N.B. and Woods, G.F., J. Org. Chem., <u>28</u>, 2517 (1973).
- 122. Sasaki, S., Nippon Kagaku Zasshi, <u>80</u>, 531 (1959); Chem. Abstr., <u>55</u>, 4422⁶ (1961).
- 123. Bar, D. and Debruyre, Mme. E., Ann. Pharm. Franc., <u>16</u>, 235 (1958).

CHAPTER - 8

PHOTOCHEMISTRY OF CHALCONES AND THEIR DERIVATIVES

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Photochemistry of Chalcones:

Photoisomerization of <u>trans</u>-chalcone, ¹ <u>trans</u>-2-hydroxy-chalcone² and other substituted chalcones, ³, ⁴ and heterocyclic analogues of chalcones⁵ into their corresponding <u>cis</u>-isomers has been described in the literature. <u>Cis</u>-2-methoxychalcone is convertible to <u>cis</u>-2-hydroxychalcone (photochemical demethylation)² by prolonged irradiation to sunlight. Some chalcones, on the other hand, have a great tendency to undergo resinification, ⁶ when irradiated either in the solid state or solution, viz., 4,4'-dimethyl (and 4,4'-dimethoxy) chalcones. The solid state photochemistry of some 2'-nitrochalcones has been studied. ⁷ Various parameters seem to govern the specific pathway followed by the photochemical reaction, viz., molecular conformation and its retention and the molecular packings.

Photochemical Dimerization:

Photochemical dimerization is reported to occur in the case of several chalcones, viz., chalcone, 6,8 4'-methyl-chalcone, 6, 4-methoxychalcone 10 and thiophene analogue 11 of chalcone. Dimerization, however, does not take place with chalcone, or 4-methoxychalcone, if these are irradiated in presence of uranyl chloride. 12 Cyclobutane type of structure 6,8 (vide infra) has been assigned to chalcone dimers. These results have been arrived at on the basis of data obtained by

physical 8,9 and chemical methods.6,8 CO¢

CO¢

(m.p. 226°)

Photo induced dimerization of 4-methoxychalcone is reported 13 to take place with the aid of 4,10-dihydroanthracene. Two types of dimerides, 13 viz., head-tail and head-head orientations are produced, when the photo-reaction is carried out in ethanol and acetonitrile respectively. Chalcone dimers, of the following structure have been obtained 14 in high yield by the photolysis of a solution of chalcone under appropriate conditions 15:

$$X-C_6H_4-CH_2-CH-CO-\emptyset$$

 $X-C_6H_4-CH_2-CH-CO-\emptyset$

(X = H; 4-OMe or 4-Cl).

Photolysis of 2-hydroxychalcone, in ethanol, is reported ¹⁶ to yield 2-ethoxy-flav-3-one (96%) and a very small amount (1%) flavone, according to the reaction:

4',6',3,4-tetramethoxychalcone leading to the formation of 5,7,3',4'-tetramethoxyflavanonol. The 3-hydroxylic function in the flavanonol is assumed to arise from the hydroxylic radical generated by the photolysis of aqueous-methanol, used as the solvent.

OEt

Photochemistry of Chalcone Derivatives

Flavanone:

UV irradiation of flavanone is reported 18 to yield three products, viz., 2'-hydroxychalcone (20%), 4-phenyl-dihydrocoumarin (13%) and salicyclic acid (4%). The mechanism 18 of the reaction is as follows:

Chalcone epoxides are reported 19 to undergo photo-oxidative cleavage yielding a mixture of acid and aldehyde. Thus, for example, 2',3,4,4'-tetramethoxychalcone epoxide 19 yields veratraldehyde and 2,4-dimethoxybenzoic acid, under these conditions. According to another report 20 trans chalcone epoxide and trans 2-methoxychalcone epoxide on irradiation yield

dibenzoylmethanes, trans-cis isomerization and fragmentation via acyl carbene intermediates. Evidence has been put forward epoxides about the intermediacy of dioxoles when substituted chalcone are photolysed. The dioxoles are produced by the cleavage of the Composition of carbonyl ylides, which subsequently rearrange to dioxoles.

Chalcone Semicarbazones:

Some of the chalcone semicarbazones are reported²² to exhibit noticeable photochemical isomerism. Examples are: p-methylchalcone and p-methoxy-p'-methylchalcone.²²

References

- 1. Tryon, M. and Wall, L.A., J. Phys. Chem., 62, 697 (1958).
- 2. Jurd, L., Tetrahedron, <u>25</u>, 2367 (1969).
- 3. Ferreira, D. and Roux, D.G., J. Chem. Soc. Perkin Transaction I, No. 2, 134 (1977).
- 4. Zahir, S.A., J. Appl. Polymer Sci., <u>23</u>, 1355 (1979).
- 5. Reinhardt, M., Mitina, V.G., Zadorozhnyi, B.A. and Lavrushin, V.F., Zh. Obshch. Khim., 48, 2759 (1978).
- 6. Stobbe, H. and Bremer, K., J. Prakt. Chem., 123, 1 (1929).
- 7. Jungk, A.E., Luwisch, M., Princhar, S. and Schmidt, G.M.J., Isr. J. Chem., <u>16</u>, 308 (1977).
- 8. Montaudo, G. and Caccamese, S., J. Org. Chem., <u>38</u>, 710 (1973).

- 9. Caccamese, S., McMillan, J.A. and Montaudo, G., J. Org. Chem., 43, 2703 (1978).
- 10. Stobbe, H. and Hensel, A., Chem. Ber., 59B, 2254 (1926).
- 11. Wynberg, H., Groen, M.B. and Kellogg, R.M., J. Org. Chem., 35, 2828 (1970).
- 12. Praetorius, P. and Korn, F., Chem. Ber., 43, 2744 (1910).
- 13. Burton, G.W., Dissertation Abstr., 25, 4400 (1965).
- 14. Sugden, J.K., Synthetic Commun., $\underline{6}$, 93 (1976).
- 15. Evans, P.G.E., Sugden, J.K. and Abbe, N.J.V., Pharm. Acta Helv., 50, 94 (1975).
- 16. Dewar, D. and Sutherland, R.G., J. Chem. Soc., D, 272 (1970).
- 17. Chawla, H.M., Chibber, S.S. and Sharma, A., Tetrahedron Letters, 2713 (1978).
- 18. Mack, P.O.L. and Pinhey, J.T., Chem. Commun., (8), 451 (1972).
- 19. Parthasarthy, M.R. and Sharma, D.K., Indian J. Chem., <u>12</u>, 1009 (1974).
- 20. Dewar, D.J. and Sutherland, R.G., J. Chem. Soc., Perkin Trans., 2, 1522 (1977).
- 21. Lee, G.A., J. Org. Chem., 43, 4256 (1978).
- 22. Heilbron, I.M. and Wilson, F.J., J. Chem. Soc., <u>103</u>, 1504 (1913).

CHAPTER - 9

POLAROGRAPHIC STUDIES OF CHALCONES, CHALCONE ANALOGUES AND THE IR DERIVATIVES

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Polarographic Reduction of Chalcone:

Chalcone undergoes reduction on a dropping mercury electrode yielding a variety of products depending upon the conditions of the experiment. The present picture about the mechanism involved in the formation of these products from chalcone, for example, has emerged as a result of the work of several investigations 1-14,17-19 and is summarized below:

to yield a saturated ketone (IV). In the neutral or alkaline media, however, the reduction proceeds past the saturated ketone stage to yield the corresponding alcohol (V). In the above reaction (I-IV) the reduction of the ethylenic bond is a secondary process connected with a rearrangement of the free radical formed after the addition of one electron and one proton to the carbonyl group (II-III). The formation of other products has been interpreted to arise either by dimerisation (VI) or disproportionation of the radicals generated in the process.

Polarographic Reduction of Chalcone in DMF:

Polarographic reduction of chalcone has been reported in anhydrous dimethylformamide, in the presence and absence of carbon dioxide. In the former case two acids, viz., - phenyl-

$$\phi - CH - CH - CO \phi$$

$$\phi - CH - CH - CO \phi$$

$$\phi - CH - CH - CO \phi$$

$$COO^{\Theta}$$

$$C$$

$$H^{\oplus}$$
 ϕ — CH — CH₂ — CO ϕ COOH (XII)

double bond of another chalcone molecule and then be reduced further to yield finally the dimeric monocarboxylic acid (XVI):



$$IX + \phi CH = CHCO \phi$$

$$\phi - CH - CH - CO \phi$$

$$\phi - CH - CH - CO \phi$$

In the absence of carbon dioxide, the charcone of and

furnishes the polymer (XVII). The polymer must have been produced by a series of Michael type addition of the dianion intermediate

$$\phi - CH - CH = C - \phi + \phi - CH = CH - CO \phi - \bullet$$

$$\phi - CH - CH = \stackrel{\downarrow}{C} - \phi$$

$$\phi - CH - CH = \stackrel{\downarrow}{C} - \phi$$

$$\phi - CH - CH = \stackrel{\downarrow}{C} - \phi$$

$$0 = 0$$

$$\phi - CH - CH = \stackrel{\downarrow}{C} - \phi$$

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$$\frac{\phi \text{CH} = \text{CHCO} \phi}{\phi - \text{CH} - \text{CH} = c - \phi}$$

$$\phi - \text{CH} - \text{CH} - \text{CO} - \phi - (\phi - c + c - c - \phi)_{\text{II}}$$

$$\phi - \text{CH} - \text{CH} - \text{CO} - \phi \qquad (\text{XVII})$$

The formation of the unsaturated trimer, (XVIII), in the polarographic reduction of chalcone (in the absence of carbon diaxide) has been assumed 9 to involve the following intermediates

$$\phi - CH - CH_2CO - \phi$$

 $\phi - CH - CH - CO - \phi$
 $\phi - CH_2 - CH - CO - \phi$

The ease of polarographic reduction is dep nature of substituents. 4,15 Thus chalcones conaining a hydroxyl4 or methoxy4,15 function (in conjugation with the carbonyl group4) are less prone to reduction as compared to chalcone bearing an acetoxy function. This effect is less pronounced in acid medium than in neutral medium. 16

Polarographic Reduction of Chalcone Analogues:

The polarographic reduction of ferrocenyl^{7,20} and heterocyclic analogues of chalcone (viz., pyrrolyl, furanyl, thienyl and pyridyl) are reported in the literature. The polarographic reduction of furan chalcone is reported to take place <u>via</u> radical anion formation.^{23,24} The behaviour of pyridyl^{21,22} analogues of chalcone in respect of polarographic reduction is similar to that of chalcone.²⁵ In alkaline medium other reactions ²⁶ manifest themselves, viz., the hydration of the double bond, followed by cyclization to chromanones ($p_{H} \sim 12.5$), which are in turn polarographically reduced further.

The polarographic reduction behaviour of chalcone has been studied 27 and compared with its acetylenic analogue, viz., 1,3-diphenyl-1-propyn-3-one.

Polarographic Analysis of 2'-hydroxychalcone-flavanone Mixture:

In weakly acidic or neutral medium chalcone shows two polarographic reduction potentials, while flavanone has only one. Based on this property it is possible to determine 2'-hydroxy-chalcone in the presence of its isomer, flavanone. Polarographic method could also be used to monitor the rate of formation of chalcone from its components.

Polarographic Conversion of 2'-hydroxychalcone to Chromanone:

A polarographic study of the transformation of orthohydroxychalcone to chromanones has been reported. 28,29 The percentage of hydroxychalcone at equilibrium is independent²⁹ of pH (range 5-9), however, with pH greater than 9, the equilibrium is displaced in favour of chalcone, attended with immediate decomposition.

Polarographic Conversion of Chalcone to Chalcone Hydrazone:

A polarographic study has been reported in respect of the reaction of chalcone with phenylhydrazine.³⁰ Conclusion has been drawn³¹ that the first step, is the reaction on mercury cathode of the carbonyl group of the chalcone.

Polarographic Behaviour of Pyridine Analogue of Chalcone Oxime:

The pyridyl analogue of chalcone oxime, 32 R₁C(NOH)-CH= CH-R₂ (R₁ = R₂ = 3-pyridyl) is reported to undergo protonation and polarographic reduction at the oximo group, and then at the olefinic linkage.

References

- 1. Pasternak, R. and Halben, H.V., Helv. Chim Acta, <u>29</u>, 190 (1946).
- 2. Pasternak, R., Helv. Chim. Acta, 31, 753 (1948).
- 3. Schraufstätter, E., Experientia, 4, 192 (1948).
- 4. Geissman, T.A. and Friess, S.L., J. Am. Chem. Soc., <u>71</u>, 3893 (1949).
- 5. Korshunov, I.A. and Vodzinskiĭ, Y.V., Zh. Fiz. Khim., <u>27</u>, 1152 (1953); Chem. Abstr., <u>48</u>, 5674^C (1954).

- 6. Vodzinskii, Y.V. and Korshunov, I.A., Uchenye Zapiski
 Gor'kovsk, Gosudarst. Univ. im N.I. Lobachevskogo, Ser. Khim.,
 32, 25 (1958); Chem. Abstr., 54, 17113h (1960).
- 7. Tirouflet, J. Laviron, E., Metzger, J. and Boichard, J., Coll. Czech. Chem. Commun., 25, 3277 (1960).
- 8. Lavrushin, V.F., Bezuglyi, V.D. and Belous, G.G., Zh. Obshch. Khim., 33, 1711 (1963).
- 9. Wawzonek, S. and Gundersen, A., J. Electrochem. Soc., 111, 324 (1964).
- 10. Ryvolova-Kejharova, A. and Zuman, P., J. Electroanal. Chem. Interfacial Electrochem., 21, 197 (1969).
- 11. Ash, M.L., O'Brien, F.L. and Boykin, D.W. (Jr.), J. Org. Chem., 37, 106 (1972).
- 12. Seguin, J.P., Doucet, J.P. and Uzan, R., C. Acad. Sci., Ser. C. 278, 129 (1974); Chem. Abstr., 80, 95024 (1974).
- 13. Taran, L.A., Berezina, S.I., Smolentseva, L.G., Kitaev, Y.P., Izv. Akad. Nauk SSSR, Ser. Khim., (11), 2611 (1974); Chem. Abstr., 82, 78456 (1975).
- 14. Katiyar, S.S., Lalithambika, M. and Dhar, D.N., J. Electroanal. Chem. Interfacial Electrochem., <u>53</u>, 449 (1974).
- 15. Lavrushin, V.F., Bezuglyi, V.D. and Belous, G.G., Zh. Obshch. Khim., 34, 13 (1964).
- 16. Bezuglyi, V.D., Lavrushin, V.F. and Belous, G.G., Zh. Obshch. Khim., 35, 606 (1965).
- 17. Yanovskaya, L.A., Umirzakov, B. and Kucherov, V.F., Izv.

 Akad. Nauk SSSR, Ser. Khim., (4), 823 (1972); Chem. Abstr.,

 77, 69365⁶ (1972).

- 18. Bala, S., and Bannerjee, N.R., Indian J. Chem., <u>15A</u>, 777 (1977).
- 19. Butkiewicz, K., J. Electroanal. Chem. Interfacial Electrochem. 89 (2), 379 (1978).
- 20. Stankoviansky, S., Beno, A., Toma, S. and Gono, E., Chem. Zvesti, <u>24</u>, 19 (1970); Chem. Abstr., <u>74</u>, 49014^Z (1971).
- 21. Butkiewicz, K., J. Electroanal. Chem. Interfacial Electrochem., 39, 419 (1972).
- 22. Butkiewicz, K., J. Electroanal. Chem. Interfacial Electrochem., <u>87</u> (1), 137 (1978).
- 23. Rusina, A., Volke, J., Cernak, J., Kovac, J. and Kollar, V., J. Electroanal. Chem. Interfacial Electrochem., <u>50</u>, 351 (1974).
- 24. Nikulin, V.N., Kargina, N.M. and Kargin, Y.M., Zh. Obshch. Khim., 44, 2520 (1974).
- 25. Nikulin, V.N., Kargina, N.M. and Kargin, Y.M., Zh. Obshch. Khim., 43, 2712 (1973).
- 26. Butkiewicz, K., J. Electroanal. Chem. Interfacial Electrochem., 39, 407 (1972).
- 27. Prevost, C., Souchay, P. and Chauvelier, J., Bull. Soc. Chim. France, 714 (1951).
- 28. Tirouflet, J. and Corvaisier, A., Bull. Soc. Chim. France, 535 (1962).
- 29. Corvaisier, A. and Tirouflet, J., Compt. Rend., <u>251</u>, 1641 (1960).

- 30. Lavrushin, V.F., Bezuglyi, V.D., Belous, G.G. and Tishchenko, V.G., Zh. Obshch. Khim., 34, 7 (1964).
- 31. Lavrushin, V.F., Bezuglyi, V.D., Belous, G.G. and Tishchenko, V.G., Zh. Organ. Khim., <u>1</u>, 98 (1965); Chem. Abstr., <u>62</u>, 14453^g (1965).
- 32. Butkiewicz, K., J. Electroanal. Chem. Interfacial Electrochem., 48, 297 (1973).

PART - III

CHAPTER - 10

PROPERTIES OF CHALCONES AND THEIR HETEROCYCLIC ANALOGUES

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Viscosity:

The specific viscosity of chalcone in benzene and carbon tetrachloride is reported to be higher compared to dihydrochalcone. At higher temperature (Ca. 60°) the decrease in specific viscosity is slightly less in benzene than in carbon tetrachloride.

Rate of Crystallization:

The rate of crystallization has been taken as a criterion of purity of chalcone.² The maximum rate of crystallization (m.r.c.), expressed as mm/minute has been reported² for the following chalcones:

Compound	M.P. (°C)	m.r.c. (temp.)
Chalcone	54.7	5.21 (30°)
p'-Ethylchalcone	61.0	1.15 (25°)
p'-Propylchalcone	45.7	3.62 (25°)

Adsorption Characteristics:

Chalcone undergo polarization and color change when these are adsorbed on surface active materials, like silica gel, acid washed alumina and Brockmann's alumina. These color changes along with the ease of their elution (by methanol) from these adsorbents² are described³ in the literature.

A study in respect of distribution of para N.N-dimethyl-chalcone (DMC) in artificial lipid membrane has been reported.⁴ DMC molecules have been found⁴ to concentrate in the polar regions — near the surface of the lipid membrane.

Quenching of Fluorescence:

Hesperatin chalcone, in contrast to hesperidin or eriodictin, is able to quench the fluorescence of chrysene solution (in

acetone) and this has been attributed⁵ to its ability to form a non-fluorescent complex.

Eutectic and Molecular Compound Formation:

Chalcone forms an eutectic with picric acid and with trichloroacetic acid. A detailed study is reported in respect of eutectic composition of the ternary system, viz., chalcone—

##-naphthol picric acid (cf. Table 1).

Table 1
Eutectic Composition

Temp.	°C	Chalcone	$oldsymbol{eta}$ -naphthol	Picric acid
70		51.5	43.0	5.5
84		58.5	16.0	25.5
103		7.5	7.5	8.5

The molecular compounds formed between chalcone (and 3,4-methylenedioxychalcone) and isomeric nitrophenols (and o-nitroto-luene) have been studied.^{8,9}

Molecular Refraction:

Refractometric studies of chalcones and some of its derivatives are reported 10,11 in the literature.

Polymorphism:

The phenomenon of polymorphism is well known in the case of chalcones. The work reported on the subject is summarized in Table 2.

Table 2
Polymorphic Forms of Chalcones

Compound	Melting point (°C) of poly- morphic forms	Remarks	Ref.
Chalcone*	59,57,49,48, 30,—	Several polymorphic forms are known. No difference is observed in the infrared spectrum of the polymorphs, recorded in the range 2222-1220 cm ⁻¹ . The dipole moment data (calcd.) for some polymorphic forms are given	12,13,15, 16,22
m-Methyl- chalcone	68,67,66,53		14
m'-Methyl- chalcone	61,51		14
p-Methyl- chalcone	99,96.5,90	Exists in three polymorphic forms	24,27
v'-Methyl- chalcone	74.5,56.5, 55.5,54.5, 45.5,48 and 44.5		26
o-Nitro- chalcone	126,123		14
m-Nitro- chalcone	146,145,120		14

$\frac{m}{c}$ -Nitro-chalcone	131,110	·	14
∠ -Bromo- chalcone	Saurana .	Exhibits polymorphism	12
B -Hydroxy- chalcone	81,78,73	Exhibits polymorphism	12,28
B -Methoxy- chalcone	81,78,65	X-ray powder diffraction, uv and IR spectral data have been recorded	12,17,18
β -Ethoxy-chalcone	81,78,75,63, 43	Polymorphism is due to the existence of rotational isomers	21,25,28
B-Propoxy- chalcone	75,.63,59	X-ray powder diffraction and UV studies have been carried out	21
/3 -Methoxy- p-nitro- chalcone	97 ⁻ ,90,78-81, 665-9,55-8	Polymorphism attributed to rotational isomers u.v. data is reported	20
/3 -Methoxy-p' -nitro- chalcone	1,21,107,104	Polymorphic forms (107,104°) possess identical x-ray powder diffraction, while the polymorph, m.p. 121° has a different pattern. Results confirmed by u.v. and IR data	19
B -Methoxy- p'-methoxy- p-nitro- chalcone	132,87,80		22
- Furfuryl - acetophenomic	60,56		13

indicaties that polymorphism has been observed, but the melting point of the polymorphs are not available.

^{*} It is reported²³ to be in a mesophase near its melting point, it is hibits a rapid increase in transmission of the infrared radio at this stage of phase change.

Basicity:

The basicity of chalcone has been determined in sulpholane and water. The pK_a value, -5.55 is reported for chalcone in sulpholane solvent, compared to -5.73 in water.

The basicity of chalcone in acetic acid is reported²⁹ to be higher than in aqueous solution. The electron donating substituents, viz., hydroxy, methoxy, methyl, increase the basicity, whereas the para substituted halogens decrease it.²⁹

The basicity of $\underline{\text{trans}}$ chalcone in concentrated sulphuric acid has been shown 30 to be more than its corresponding $\underline{\text{cis}}$ isomer.

Protolytic equilibrium in respect of substituted chalcones 31,32 and thiophene analogues 33 have been studied in acetic acid-sulphuric acid system. The comparison of relative basicities of these chalcones have been made. 31,33 Correlation has been found between the protonation data and the 5-constants. 31

Substitution of the phenyl ring of chalcone by either furan 34 or thiophene moiety 35-37 increase the basicity. The effect is reported 34,37 to be pronounced when the heterocyclic moiety is located further away from the carbonyl group. Comparative studies in respect of basicities of heterocyclic chalcone analogues have been published. 38-40

Hydrogen Bonding:

The energy of hydrogen bonding involved in phenol and

various chalcones, in carbon tetrachloride has been determined. 41

The thermodynamic data for the (1:1) association of the above system has been reported. 42

The association constants have been shown 43 to be a sensitive measure of the proton-acceptor power of chalcones than the shifts of the I.R. and N.M.R. absorption bands.

Based on uv absorption data, the energy of the hydrogen bond formed between various substituted chalcones and trichloro-acetic acid has been found 44,45 to lie in the range 1.79-2.40 kcal/mole. Also, the Δ H values, 46 calculated from the equilibrium constants at various temperatures, have been shown to vary from 2-3 kcal/mole.

The hydrogen bonding of 2,3,4,6-tetrachlorophenol with various chalcones have been studied⁴³ by infrared and N.M.R. spectroscopy.

Electronic Effects:

The influence of several functional groups on the activity of methyl group in chalcone has been investigated. 47

The quantum-chemical interpretation of reactivity of substituted chalcones (benzene and ferrocene type) has been made. 48 The effect of substituents on the 77-electron structure and reactivity of monosubstituted trans chalcones has been studied. 49

The influence of transmission of electronic effects in Z and E isomers of — phenyl-4-substituted chalcones has been investigated. ⁵⁰ Z and E isomers are reported ⁵⁰ to be insensitive to substituent effects.

Halochromism:

The phenomenon of halochromism is reported for substituted chalcones 51-56 and their heterocyclic analogues containing either a furan, 57,58 thiophene, 59,61 selenophene or quinoline a furan, 57,58 thiophene, 59,61 selenophene or quinoline aucleus. These chalcones develop halochromic colors when wetted with concentrated sulphuric acid. The deepening in color may be rationalized in terms of the formation of carbonium ions in concentrated sulphuric acid.

Methoxychalcones, ⁵⁶ for example, also exhibit halochromism with other mineral acids, viz., hydrochloric and phosphoric acids. The color is reported ⁵⁶ to deepen with increase in the number of methoxy groups.

The influence of various substituents on the halochromy of these compounds in concentrated sulphuric acid is described 51-54 in the literature. In the case of quinoline analogue of chalcone, the halochromic color deepens when the heterocyclic residue is located closer to the carbonyl group. 62

References

- 1. Studinger, H., Steinhofer, A. and Bauer, R.C., Ann., <u>517</u>, 54 (1935).
- 2. Michel, J., Bull. Soc. Chim. Belges, <u>48</u>, 105 (1939); Chem. Abstr., <u>33</u>, **7**650⁷ (1939).
- 3. Weitz, E., Schmidt, F. and Singer, J., Z. Electrochem., <u>46</u>, 222 (1940).
- Dobretsov, G.E., Petrov, V.A., Deev, A.I. and Vladimirov,
 Y.A., Biofizika, 20, 1014 (1975); Chem. Abstr., 84, 55578^j
 (1976).
- 5. McLaughlin, J.A. and Szent-Gyorgyi, A., Enzymologia, <u>16</u>, 384 (1954); Chem. Abstr., <u>49</u>, 10066^h (1955).
- 6. Campbell, N. and Woodham, A.A., J. Chem. Soc., 843 (1952).
- 7. Asahina, T. and Yokoyama, K., J. Chem. Soc. Japan, <u>56</u>, 415 (1935).
- 8. Asahina, T., J. Chem. Soc. Japan, <u>54</u>, 527 (1933).
- 9. Asahina, T., Bull. Chem. Soc. Japan, 9, 181 (1934).
- 10. Volovik, A.M., Tolmachev, V.N. and Lavrushin, V.F., Visn. Kharkiv, Univ., <u>73</u>, 85 (1971); Chem. Abstr., <u>78</u>, 57241^u (1973).
- 11. Tolmachev, V.N., Volovik, A.M. and Lavrushin, V.F., Zh. Obshch. Khim., 44, 1810 (1974).
- 12. Weygand, C., Ann., 472, 143 (1929).
- 13. Weygand, C., Chem. Ber., 62B, 2603 (1929).
- 14. Weygand, C. and Schächer, F., Chem. Ber., 68B, 227 (1935).

- 15. LeFevre, R.J.W., J. Chem. Soc., 1037 (1937).
- 16. Guy, J., Ann. Phys., (12), <u>4</u>, 704 (1949); Chem. Abstr., <u>44</u>, 10439^d (1950).
- 17. Eistert, B., Weygand, F. and Csendes, E., Chem. Ber., <u>85</u>, 164 (1952).
- 18. Ikeda, K., J. Chem. Soc. Japan, 76, 899 (1955).
- 19. Ikeda, K., J. Chem. Soc. Japan, 896 (1955).
- 20. Iimura, F., Nippon Kagaku Zasshi, <u>77</u>, 1851 (1956); Chem. Abstr., <u>53</u>, 5192^h (1959).
- 21. Ikeda, K., Nippon Kagaku Zasshi, <u>78</u>, 302 (1957); Chem. Abstr., <u>53</u>, 5192^d (1959).
- 22. Guy, J., Bull. Soc. Chim. France, 731 (1949).
- 23. Taschek, R.F. and Williams, D., J. Chem. Phys., 7, 11 (1939).
- 24. Weygand, C. and Matthes, A., Chem. Ber., 59B, 2247 (1926).
- 25. Weygand, C. and Hennig, H., Chem. Ber., 59B, 2249 (1926).
- 26. Weygand, C. and Baumgartel, H., Ann., 469, 225 (1929).
- 27. Weygand, C., Chem. Ber., 60B, 2428 (1927).
- 28. Weygand, C., Bauer, E. and Hennig, H., Chem. Ber., <u>62B</u>, 562 (1929).
- 29. Tsukerman, S.V., Kutulya, L.A., Lavrushin, V.F. and Thuy, N.M., Zh. Fiz. Khim., <u>42</u>, 1930 (1968); Chem. Abstr., <u>70</u>, 19471^W (1969).
- 30. Noyce, D.S. and Jorgenson, M.J., J. Am. Chem. Soc., <u>84</u>, 4312 (1962).

- 31. Trusevish, N.D., Lavrushin, V.F., Tolmachev, V.N. and Borodin, V.N., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol, 16, 1677 (1973); Chem. Abstr., 80, 59270^t (1974).
- 32. Trusevich, N.D., Tolmachev, V.N. and Lavrushin, V.F.,
 Vestn. Khar'kov Un-t, Khimiya, <u>127</u>, 98 (1975); Chem. Abstr.,
 84, 134982^q (1976).
- 33. Konate, B., Trusevish, N.D., Nikitchenko, V.M. and Lavrushin, V.F., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., 18, 1703 (1975); Chem. Abstr., 84, 73484^e (1976).
- 34. Tsukerman, S.V., Kutulya, L.A. and Lavrushin, V.F., Khim. Geterotsikl Soedin., Akad. Nauk. Latv. SSR, (6), 803 (1965); Chem. Abstr., 64, 12521^e (1966).
- 35. Tsukerman, S.V., Kutulya, L.A., Nikitchenko, V.M. and Lavrushin, V.F., Tr. Konf. Po. Probl. Primeneniya Korrelyatsion Uravnenii v Organ. Khim. Tartu, 1, 309 (1962); Chem. Abstr., 61, 1740^g (1964).
- 36. Tsukerman, S.V., Kutulya, L.A., Surov, Y.N., Lavrushin, V.F. and Yur'ev, Y.K., Doklady Akad. Nauk. SSSR, <u>164</u>, 354 (1965); Chem. Abstr., 63, 18006^C (1965).
- 37. Tsukerman, S.V., Kutulya, L.A. and Nikitchenko, V.M., Zh. Obsch. Khim., <u>33</u>, 3180 (1963).
- 38. Tsukerman, S.V., Kutulya, L.A., Surov, Y.N. and Lavrushin, V.F., Khim. Geterotsikl. Soedin., (9), 1176 (1970); Chem. Abstr., 74, 87024 (1971).

- 39. Tsukerman, S.V., Surov, Y.N., Lavrushin, V.F. and Yurev, Y.K., Khim. Geterotsikl. Soedin., (6), 868 (1966); Chem. Abstr., 67, 32232^b (1967).
- 40. Tsukerman, S.V., Kutulya, L.A., Lavrushin, V.F. and Yur'ev, Y.K., Khim. Geterotsikl. Soedin., Akad. Nauk. Latv. SSR, (3), 376 (1966); Chem. Abstr., 65, 12093^h (1966).
- 41. Katsui, G. and Kuyama, H., Vitamins (Kyoto), <u>11</u>, 197 (1956); Chem. Abstr., <u>51</u>, 18472ⁱ (1957).
- 42. Gramstad, T., Spectrochim. Acta, 19, 497 (1963).
- 43. Tsukerman, S.V., Kutulya, L.A., Surov, Y.N., Pivnenko, N.S. and Lavrushin, V.F., Zh. Obshch. Khim., 40, 1337 (1970).
- 44. Lavrushin, V.F., Tolmachov, V.M., Sinyagovskaya, L.A. and Trusevich, N.D., Zh. Obshch. Khim., 35, 1534 (1965).
- 45. Lavrushin, V.F., Tolmachov, V.M., Trusevich, N.D. and Sinyagovskaya, L.A., Zh. Obsch. Khim., 35, 1730 (1965).
- 46. Lavrushin, V.F., Trusevich, N.D., Tolmachev, V.N. and Semenov, A.I., Zh. Obsch. Khim., 39, 42 (1969).
- 47. Villard, C., Bull. Soc. Fribourg. Sci. nat., <u>47</u>, 20 (1957); Chem. Abstr., <u>54</u>, 14238^d (1960).
- 48. Zahradnik, P. and Leska, J., Coll. Czech. Chem. Commun., 36, 44 (1971).
- 49. Leska, J. and Zahradnik, P., Coll. Czech. Chem. Commun., 38, 3365 (1973).
- 50. Duke, P.J. and Boykin, D.W. (Jr.), J. Org. Chem., <u>37</u>, 1436 (1972).

- 51. Kauffmann, H. and Kieser, F., Chem. Ber., 46, 3788 (1913).
- 52. Dilthey, W., Neuhaus, L., Reis, E. and Schommer, W., J. Prakt. Chem., 124, 81 (1930).
- 53. Dilthey, W., Blankenburg, C., Bradt, W., Braun, W., Dinklage, R., Huthwelker, W. and Schommer, W., J. Prakt. Chem., 129, 189 (1931).
- 54. Pfeiffer, P. and Kleu, H., Chem. Ber., 66B, 1058 (1933).
- 55. Lavrushin, V.F., Verkhovod, N.N., Ukr. Khim. Zh., <u>40</u>, 506 (1974); Chem. Abstr., <u>81</u>, 119418^e (1974).
- 56. Kuroda, C. and Matsukuma, T., Sci. Papers Inst. Phys. Chem. Research (Tokyo), <u>18</u>, 51 (1932); Chem. Abstr., <u>26</u> 2442⁸ (1932).
- 57. Lavrushin, V.F., Tsukerman, S.V. and Artemenko, Λ.Ι., Zh. Obshch. Khim., 32, 2551 (1962).
- 58. Tsukerman, S.V., Artemenko, A.I. and Lavrushin, V.F., Zh. Obshch. Khim., 33, 3528 (1963).
- 59. Tsukerman, S.V., Nikitchenko, V.M. and Lavrushin, V.F., Zh. Obshch. Khim., 33, 1255 (1963).
- 60. Tsukerman, S.V., Orlov, V.D. and Lavrushin, V.F., Khim. Str., Svoistva Reaktivnost Org. Soedin., 63 (1969); Chem. Abstr., 72, 99698^e (1970).
- 61. Lavrushin, V.F., Pogonina, R.I. and Izvekov, V.P., Khim. Geterotsikl. Soedin., 7, 1361 (1971); Chem. Abstr., 76, 58463^p (1972).
- 62. Tsukerman, S.V., Ch'ang, K.S. and Lavrushin, V.F., Zh. Obshch. Khim., 35, 1723 (1965).

CHAPTER - 11

COMPLEXING ACTION OF CHALCONES AND THEIR DERIVATIVES

Chalcones serve as starting materials for the preparation of ligands suitable for the quantitative precipitation of several metallic ions. This, therefore, forms the basis for their gravimetric estimation. The following two examples 1-4 are illustrative:

2'-Hydroxy-4-methoxy-5'-methyl chalcone oxime¹⁻³ has been employed for the gravimetric estimation of divalent ions of palladium, copper and nickel either separately or in combination.

2,4,6-Triphenylpyrylium chloride, 4 preparable from chalcone, has been used as a precipitant in the gravimetric estimation of gold and platinum.

A method of separation of palladium (II) from copper (II) involving the use of 2'-hydroxy-5'-methylchalcone oxime (as complexing agent) has been developed. It is based on extraction, with a suitable solvent, of the resulting organo-metallic complex, at a definite pH. The constituents thus separated have been determined spectrophotometrically. 2'-Hydroxy-3'-bromo-4-methoxy-5'-methylchalcone oxime has been successfully employed in place of the aforesaid complexing agent.

A spectrophotometric method of estimating beryllium, using 2'-hydroxychalcone has been described. Hydroxychalcones have been exploited as specific precipitants, (in the

presence of EDTA) for beryllium when present in combination with aluminium. Copper is reported to react with 2'-hydroxy-chalcone to form a complex which has a 1:2 stoichiometry. On the basis of this reaction, a conductometric method of estimation of copper has been developed. Calcium has been determined by complexometric titration by using chalconemetanil as indicator.

The 1:1 complexes formed by the interaction of 2,2'-dihydroxychalcone (sodium salt) with the ions of copper (II), nickel (II) and tin (IV) have been studied. 11-14 The formation constants of several 1:1 complexes, derived from the interaction of several metallic ions with 2'-hydroxychalcone 15,16 and 2',4'-dihydroxychalcone, 17 have been determined.

The preparation of complexes derived from the reaction of 2'-hydroxychalcones with tri- and tetracarbonyl of iron, have been reported. 18

There are several reports ^{19,22-24,26-31} in the literature about the preparation, spectroscopic and conductometric studies of the intermolecular complexes formed between chalcones and the halides of the following elements. Ti, ¹⁹⁻²¹ Fe, ²⁶ Zn, ²⁴ La, ²³ Ce, ²¹ Pr, ²³ Sm, ²³ Eu, ²³ B, ^{24,25} Al, ²⁶ Si, ²² Ge, ²² Sn, ^{22,26} and Sb. ²⁶⁻³¹

The complexes of chalcones with antimony pentachloride have, however, been studied in detail. Thus, on the basis of conductometric measurements, the existence of the following species have been proposed ²⁷:

where n = 1 or 2.

There are two factors of paramount importance in respect of conductivity of the above complex, ²⁷ in benzene solution, viz., temperature and the electron donating ability of the substituents in the chalcone component.

References

- 1. Deshmukh, B.K., Vyas, C.N. and Kharat, R.B., J. Indian Chem. Soc., <u>52</u>, 385 (1975).
- 2. Deshmukh, B.K., Gholse, S.B. and Kharat, R.B., Fresenius Z. Anal. Chem., 279, 363 (1976).
- 3. Deshmukh, B.K. and Kharat, R.B., Indian J. Chem., 14A, 214 (1976).
- 4. Chadwick, T.C., Anal. Chem., 46, 1326 (1974).
- 5. Deshmukh, B.K. and Kharat, R.B., Fresenius Z. Anal. Chem., 276, 299 (1975).
- 6. Deshmukh, B.K. and Kharat, R.B., J. Indian Chem. Soc., <u>56</u>, 213 (1979).
- 7. Naidu, R.R., Proc. Indian Acad. Sci., <u>75A</u>, 124 (1972).
- 8. Naidu, R.R., Talanta, <u>22</u>, 614 (1975).
- 9. Naidu, R.S. and Naidu, R.R., Proc. Indian Acad. Sci., <u>82A</u>, 142 (1975).

- 10. Yavorskaya, G.M., Kazak, R.V. and Lebedev, O.P.,
 Otkrytiya, Izobret. Prom. Obraztsy. Tovarnye. Znaki., 55,
 147 (1978); Chem. Abstr., 89, 70457 (1978).
- 11. Biradar, N.S., Patil, B.R. and Kulkarni, V.H., Monatsh. Chem., <u>107</u>, 251 (1976).
- 12. Biradar, N.S., Patil, B.R. and Kulkarni, V.H., Inorg. Chim. Acta, <u>15</u>, 33 (1975).
- 13. Biradar, N.S., Patil, B.R. and Kulkarni, V.H., Current Sci., 45, 203 (1976).
- 14. Biradar, N.S., Patil, B.R., Kulkarni, V.H., Rev. Roum.
 Chim., <u>22</u>, 1479 (1977); Chem. Abstr., <u>88</u>, 98463^t (1978).
- 15. Khadikar, P.V., Kakkar, S.N. and Berge, D.D., Indian J. Chem., 13, 844 (1975).
- 16. Kakkar, S.N. and Khadikar, P.V., J. Indian Chem. Soc., <u>54</u>, 667 (1977).
- 17. Khadikar, P.V., Kakkar, S.N. and Berge, D.D., Indian J. Chem., <u>12</u>, 1319 (1974).
- 18. Brodie, A.M., Johnson, B.F.G., Josty, P.L. and Lewis, J., J. Chem. Soc. Dalton Trans. (18), 2031 (1972).
- 19. Evard, F., Compt. Rend., 196, 2007 (1933).

~ · · ·

- 20. Biradar, N.S. and Patil, B.R., Rev. Roun. Chim., <u>23</u>, 1425 (1978); Chem. Abstr., <u>90</u>, 114211ⁿ (1979).
- 21. Biradar, N.S. and Angdi, S.D., Monatsh. Chem., 109, 1365 (1978).

- 22. Shelepina, V.L., Osipov, O.A. and Shelepin, O.E., Issled.

 Termogr. Korroz., 201 (1970); Chem. Abstr., <u>76</u>, 20792^g

 (1972).
- 23. Spacu, P. and Plostinaru, S., Rev. Roum. Chim., <u>14</u>, 591 (1969); Chem. Abstr., <u>71</u>, 105874^g (1969).
- 24. Efimov, A.A., Betin, O.I., Panasenko, A.I. and Starkov, S.P., Zh. Prikl. Spektrosk., <u>23</u>, 1054 (1975); Chem. Abstr., <u>84</u>, 97290^q (1976).
- 25. Surov, Y.N., Shkumat, A.P., Nikitchenko, V.M., Tsukerman, S.V. and Lavrushin, V.F., Zh. Obshch. Khim., 49, 873 (1979).
- 26. Tomas, F., Carpena, O. and Mataix, J., An. Quim., <u>68</u>, 115 (1972); Chem. Abstr., <u>77</u>, 75418^r (1972).
- 27. Tolmachev, V.N., Volovik, A.M. and Lavrushin, V.F., Zh. Obshch. Khim., 40, 275 (1970).
- 28. Yushko, V.K., Tolmachev, V.N. and Lavrushin, V.P., Zh. Obshch. Khim., <u>40</u>, 1518 (1970).
- 29. Tolmachev, V.N., Volovik, A.M. and Lavrushin, V.F., Zh. Neorg. Khim., <u>14</u>, 1572 (1969); Chem. Abstr., <u>71</u>, 64891^q (1969).
- 30. Lavrushin, V.F., Yushko, V.K. and Tolmachev, V.N., Zh. Obshch. Khim., 40, 156 (1970).
- 31. Yushko, V.K., Tolmachev, V.N. and Lavrushin, V.F., Zh. Obshch. Khim., <u>40</u>, 160 (1970).

CHAPTER - 12

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COLOUR	REACTIONS.	DETECTION	AND	ESTIMATION	() H,	CHALICONES

Colour Reacti	ions						
With Sul	lphuric	Acid-Nitric	Acid			• • •	• •
Sul	lphuric	Acid-Acetic	Anhydride		• • • •	• •	
Soc	dium Bor	ohydride-Hyd	drochloric A	cid	• • • •		••
Wilson Boric	Acid Te	st		· · · · · · ·		• • •	• •
Antimony Pen	tachlori	de Test	* • • • • • • • • • • •			• • •	• •
Detection and	d Estima	ation of Chal	lcone(s)	· · • · • •			•
References							

# Colour Reactions

# With Sulphuric Acid-Nitric Acid1:

When the intensely coloured solution of chalcone in concentrated sulphuric acid is treated with a little of concentrated nitric acid, characteristic colour changes occur. This is typified by the following examples:

Chalcone: Orange -- yellow

4-Methoxychalcone: Orange red --- yellow

Cinnamylideneacetophenone: Cherry red -- dark yellow.

This change involve nitration of chalcone, rather than oxidation, and the resulting nitrochalcones exhibit weaker halochromy as compared to unsubstituted chalcone.

# With Sulphuric Acid-Acetic Anhydride:

The differing halochromic effects produced with concentrated sulphuric acid serve to characterize chalcones. Carbonium ions are believed to be formed as intermediates in this reaction. A large bathochromic shift in the visible colour appears if acetic anhydride is incorporated with sulphuric acid. Thus, on treatment with a 200:1 (V/V) mixture of acetic anhydride-sulphuric acid, chalcones gave orange to purple colours²:

3,4,4'-Trihydroxychalcone		
	· · · · Orange	
3,4'-Dihydroxy-4-methoxychalcone	· · · · Cerise	
3,4,4'-Tribenzyloxychalcone	· · · · Red	
3,4,4'-Trimethoxychalcone	· · · · Purnle	

The bathochromic shift arising due to the addition of acetic anhydride to the chalcones (in concentrated sulphuric acid) has been rationalized in terms of stability conferred on the carbonium ion by acetylation with acetic anhydride. This is

#### With Sodium Borohydride and Hydrochloric Acid:

Transient colours are developed when chalcones, after reduction with sodium borohydride, are treated with concentrated hydrochloric acid. This colour test can, therefore, be utilized for their identification. Table 1 lists the absorption maxima recorded after the chalcones were subjected to the aforesaid test³:

Table 1

Chalcone	$\sum_{\max}$ (nm)
4'-Hydroxychalcone	480-485
4-Methoxychalcone	550
4,4'-Dimethoxychalcone	565
2'-Hydroxy-4,4',6-trimethoxychalcone	540
2'-Hydroxy-3,4,4',6'-tetramethoxychalcone	560
4-Dimethylaminochalcone	495
2'-Hydroxy-4,4-dimethyleminochalcone	550

# Wilson's Boric Acid Test:

The test consists in reacting chalcones with boric acid-citric acid mixture in acetone solution, when a coloration is developed. Partially methylated hesperetin chalcone is reported⁴ to give a positive test. The boric acid-citric acid test is very specific for 5-hydroxy and methoxychalcones.⁵

# Antimony Pentachloride Test⁶:

Antimony pentachloride in carbon tetrachloride gives with various chalcones, intense red or violet precipitates, which are characteristically different from the precipitates from flavones, flavanones and flavanols, which are yellow or orange. A positive test is obtained with the chalcones listed in Table 2.

Chalcone	Colour
2-Hydroxy-2-methoxychalcone	Blood red
2-Hydroxy-4,5-dimethoxychalcone	Red
2-Hydroxy-4,4'-dimethoxychalcone	Red
2-Hydroxy-4',4,5-trimethoxychalcone	Blood red
2-Hydroxy-3,4,4'-trimethoxychalcone	Red
2-Hydroxy-3,4,5-trimethoxychalcone	Red
2-Hydroxy-4,5-dimethoxy-3',4'-methylenedioxychaloone	Cherry red
2-Hydroxy-3,4,4',6-tetramethoxychalcone	Red
2-Hydroxy-3,3',4,4',5-pentamethoxychalcone	Cherry red
2-Hydroxy-3,4,4',5-tetramethoxychalcone	Brick red
2,2'-Dihydroxy-3',4',5,6,6'-pentamethoxychalcone	Violet red
3,6-Dihydroxy-2,4,4'-trimethoxychalcone	Violet red
4-Methoxychalcone	Red
3',4'-Dimethoxychalcone	Cherry red

#### Table 2 (continued)

3',4'-Methylenedioxychalcone	Violet red
2',4,4-Trimethoxychalcone	Red
2,4,4',6-Tetramethoxychalcone	Dark red
2,3,4,4',5-Pentamethoxychalcone	Red
2,3,4-Trimethoxy-3',4'-methylenedioxychalcone	Cherry red

Antimony pentachloride reaction is an extremely sensitive test. For example, 2-hydroxy-3,4,4'-trimethoxychalcone, can be detected in as low a concentration as 1 part per million.

The colour reactions by chalcones with various reagents are reported in the literature.

# Detection and Estimation of Chalcone(s):

A spot test for chalcone has been developed.  8  It is based on the pyrolytic oxidative cleavage of chalcone by lead dioxide. Benzaldehyde - the product of reaction - is identified (identification limit:  $50 \, \text{V}$ ) by the appearance of yellow colour with thiobarbituric acid and phosphoric acid.

Chalcone may also be characterized by chromatography of its 2,4-dinitrophenylhydrazone  9  (R_f, 0.54) on paper, impregnated with diethyl ether - N,N-dimethylformamide-tetrahydrofuran (85 : 15 : 4; V/V).

A scheme is reported for the qualitative identification of two chalcones, ¹⁰ e.g., methylchalcone and tetramethoxy-eriodictyolchalcone, following separation by paper chromatography.

The chalcone (identification limit:  $5\Upsilon$ ) on the chromatogram is revealed as a yellow fluorescent spot, after spraying it with isonicotinic acid hydrazide reagent.

Methods for the separation and subsequent identification of chalcone in lemon oil are described in the literature. 11,12

According to one method, 12 TLC has been employed for the purpose, using ethylacetate-hexane (3:2) as the eluotropic solvent.

Various chromogenic reagents are available for identification, which include concentrated hydrochloric acid, antimony trichloride (chloroform solution), 2,4-dinitrophenylhydrazine and nicotinic acid hydrazide.

For quantitative estimation 12 of chalcones in lemon oil, the latter is reacted with nicotinic acid hydrazide and after 2 hours, absorbance of the reaction mixture is recorded at around 404 nm, by means of a spectrophotometer. Alternatively, chalcones may be determined gravimetrically 13 by utilizing that reaction with 2,4-dinitrophenylhydrazine. A spectrophotometric method for the determination of 2',4'-dihydroxychalcone and 7-hydroxyflavanone has been developed. 14 For this purpose the absorbance of the alcoholic solution of the mixture is measured at 320 nm.

p-substituted benzohydrazides (X-C₆H₄CONHNH₂; X = NO₂, Br or I) have been recommended  $^{15-17}$  as reagents for the identification of chalcone. The melting points of the hydrazones are claimed  17  to differ sufficiently to make identification possible, without the determination of mixed melting points:

Compound	m.p.
Chalcone-p-nitrobenzohydrazone	232°
Chalcone-p-bromobenzohydrazone	170 °
Chalcone-p-iodobenzohydrazone	182°

#### References

- 1. Reddelien, G., Chem. Ber., 45, 2904 (1912).
- 2. King, H.G.C. and White, T., J. Chem. Soc., 3539 (1961).
- 3. Krishnamurty, H.G. and Seshadri, T.R., Current Sci., 34, 681 (1965).
- 4. Anderson, J.R., O'Brien, K.G. and Reuter, F.H., Anal. Chem. Acta, 7, 226 (1952).
- 5. Rangaswami, S. and Seshadri, T.R., Proc. Indian Acad. Sci., 16A, 129 (1942).
- 6. Marini-Bettolo, G.B. and Ballio, A., Gazz. Chim. Ital., <u>76</u>, 410 (1946).
- 7. Paris, R. and Cornilleau, J., Ann. Pharm. Franc., <u>13</u>, 192 (1955); Chem. Abstr., 50, 4457^h (1956).
- 8. Feigl, F., Ben-Dor, L. and Cohen, R., Mikrochim. Acta, (6), 1181 (1964).
- 9. Barber, E.D. and Sawicki, E., Anal. Chem., 40, 984 (1968).
- 10. Hawker, C.D., Margraf, H.W. and Weichselbaum, T.E., Anal. Chem., 32, 122 (1960).
- 11. Stanley, W.L., J. Assoc. Offic. Agr. Chemists, <u>44</u>, 546 (1961); Chem. Abstr., <u>55</u>, 22649^h (1961).

- 12. D'Amore, G. and Sergi, G., Rass. Chim., <u>18</u>, 8 (1966); Chem. Abstr., <u>65</u>, 6994^e (1966).
- 13. Davey, W. and Gwilt, J.R., Chem. and Ind. (London), 911 (1956).
- 14. Panasenko, A.I. and Starkov, S.P., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., 19, 664 (1976); Chem. Abstr., 85, 103504^b (1976).
- 15. Chen, P., J. Chinese Chem. Soc., <u>3</u>, 251 (1935); Chem. Abstr., <u>29</u>, 7229⁸ (1935).
- 16. Wang, S-M., Kao, Chen-Heng, Kao, Chung-Hsi and Sah, P.P.T., Science Repts. Natl. Tsinghau Univ., <u>A3</u>, 279 (1935); Chem. Abstr., <u>30</u>, 2875⁸ (1936).
- 17. Sah, P.P.T. and Hsu, C-L., Rec. Trav. Chim., <u>59</u>, **3**49 (1940); Chem. Abstr., <u>35</u>, 4363¹ (1941).

#### CHAPTER - 13.1

#### STEREOISOMETRISM IN CHALCONES AND THEIR DERIVATIVES

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#### Introduction:

The stereoisomers of chalcone have been examined in respect of their physical (colour, crystallography and transmutation) and chemical properties. It exists in several forms, presumably arising due to polymorphism and/or stereoisomerism. The introduction of methoxy or ethoxy group in the  $\beta$ -position of chalcone molecule exert different effects on isomerism. Conclusion has been drawn that mass of the groups about the olefinic system and particularly their spatial effects, determine the number of isomers obtainable in a given case.

The relationship between polymorphism and stereoisomerism in respect of substituted chalcones has been discussed.³

The  $\angle$  -bromo- $\beta$ -methoxychalcone⁴ exists in two stereo-isomeric forms. The most stable form has the highest melting point and is easier to isolate.⁴ The stereoisomers have been interconverted into each other under appropriate experimental conditions.⁶

 $\measuredangle$  -Bromo- $\beta$  -methoxy (and  $\beta$  -ethoxy) chalcones also exist in several crystalline forms with different melting points. ⁵ However, their homologue, viz.,  $\measuredangle$  -bromo- $\beta$ -propoxychalcone exists only in one form.

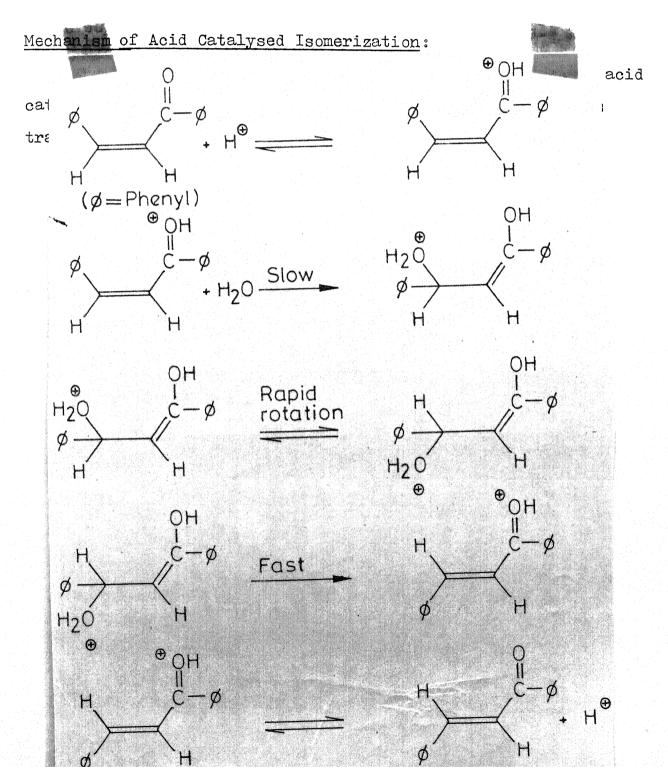
# Cis-trans Isomerism:

There are various reports  $^{7-12}$  about the existence of geometrical isomers of chalcones. The well-known examples are: chalcone,  $^{7-9}$  —phenylchalcone,  11,20   $\beta$  —tolylchalcone  10  and —phenyl-nitrochalcone.  12 

The partial transformation of <u>trans</u>-chalcones into stereoisomeric pairs have been accomplished either by irradiation of their solution (in pentane or iso-octane) to sunlight or by treatment with anhydrous aluminium chloride. 13,23 The percentage of <u>cis</u>- and <u>trans</u>-isomers formed on irradiation is reported to vary greatly from one chalcone to another. The reverse conversion from <u>cis</u> to its stereoisomeric pair can be effected thermally or by acid catalysis. 8

The ultraviolet spectra of <u>cis-trans</u> isomers of chalcones have been studied. 15-17 Their spectra are quite different with a large extinction coefficient for the more stable <u>trans</u> isomer.

In the acid catalysed isomerisation of <u>cis</u> to <u>trans</u> chalcone either of the following mechanisms (A and B) are involved:



The rate controlling process is the addition of water to the conjugate acid (oxonium salt) of cis-chalcone. Following this slow step, rapid rotation about the C-C bond occurs, and this is followed by dehydration. The mechanism outlined above finds support in the deuterium isotope studies on this transformation.

# Mechanism B (Carbonium ion mechanism):

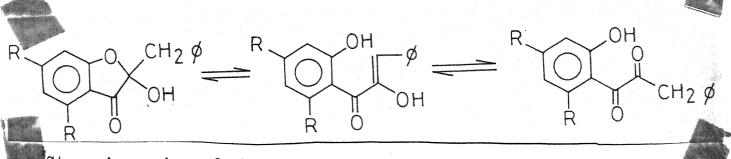
The salt of the ketone (II), is resonance stabilized and undergoes rotation about  $C_{a}$  -  $C_{\beta}$  bond without the addition of water.

The isomerization may change from mechanism (A) to mechanism (B) depending upon the substituents present in the chalcone molecule, as well as on the conditions of experiment. 19 Thus, introduction of a methoxy group in the 2-, 4- and 6positions will exert a very great influence on the stability of the postulated benzylic carbonium ion (II) and thus favours isomerisation by the latter mechanism. Also, by reducing the activity of water the rate of isomerisation by mechanism (A) may be reduced and thus allow mechanism (B) to become competitive. Besides, the introduction of ortho substituents will provide some steric interference to the addition of water at the  $oldsymbol{eta}$  carbon and likewise allow the carbonium ion mechanism to become competitive. The isomerisation of cis-chalcone into transchalcone occurs in 78% sulphuric acid via mechanism (A), while mechanism (B) operates when the reaction is carried out in a sufficiently concentrated sulphuric acid (96%).

The mechanism and kinetics of <u>cis-trans</u> photoisomerization of chalcone has been reported.²¹ The reaction has been described²¹ to take place by a triplet mechanism, wherein a direct conversion of the twisted state of one isomer to the ground state of the other takes place.

# Tautomerism in < -Hydroxychalcone:

A-Hydroxychalcone is reported²² to exhibit tautomerism.
It exists in equilibrium with corresponding Coumaran-3-one and the diketone,²² thus:



# Stereoisomerism of Chalcone Semicarbazones

# Chalcone Semicarbazones:

Chalcone react with semicarbazide in acetic acid medium to give three isomeric semicarbazones  24  ( $\checkmark$ ,  $\beta$  and  $\checkmark$ -). According to Hantzsch-Wenrner hypothesis four semicarbazones (V-VIII) are

$$\phi - C - H$$
 $H - C - C - \phi$ 
 isomers of chalcone phenyl semicarbazone. 25

## Chalcone Thiosemicarbazones:

Thiosemicarbazone of substituted chalcones (with substitution in both the aromatic rings) are described in literature. The thiosemicarbazone of chalcone and 2-nitrochalcone are reported 27 to exhibit prototropic and thermochromic properties.

Chalcone semicarbazone and thiosemicarbazone formed under acid catalysis, are reported 28 to have <u>trans</u> and <u>anti</u> configuration, with respect to the olefinic hydrogens. On the other hand, <u>cis</u> and <u>syn</u> products are formed in the base catalysed reaction.

Chalcone semicarbazone derivatives are claimed ^{29,30} to be useful for characterisation of chalcone. For the preparation of these derivatives the following two reagents have been recommended, viz., 2,4-dinitrophenyl semicarbazide ²⁹ and —naphthyl-semicarbazide. ³⁰ The reagents can readily be prepared by the interaction of hydrazine hydrate with the appropriately substituted urea in alcoholic solution.

# References

- Dufraisse, C., Ann. Chim. (France), <u>17</u>, 133 (1972); Chem.
   Abstr., <u>16</u>, 2328⁵ (1922).
- 2. Dufraisse, C. and Gillet, A., Compt. Rend., 183, 746 (1926).
- 3. Weygand, C., Chem. Ber., 62B, 562 (1929).
- 4. Dufraisse, C. and Gillet, A., Compt. Reth., 178, 948 (1924).
- Dufraisse, C. and Gillet, A., Ann. Chim. (France), 11,
   (1929); Chem. Abstr., 23, 4941⁸ (1929).

- 6. Dufraisse, C. and Netter, R., Compt. Rend., <u>189</u>, **299**. (1929).
- 7. Lutz, R.E. and Jordan, R.H., J. Am. Chem. Soc., <u>72</u>, 4090 (1950).
- 8. Noyce, D.S., Pryor, W.A. and King, P.A., J. Am. Chem. Soc., 81, 5423 (1959).
- 9. Noyce, D.S., Woo, G.L. and Jorgenson, M.J., J. Am. Chem. Soc., 83, 1160 (1961).
- 10. Badoche, M., Bull. Soc. Chim. France, <u>43</u>, 337 (1928).
- 11. Pascual-Vila, J., Anales Soc. espan. fis. quim., <u>26</u>, 222 (1928); Chem. Abstr., <u>23</u>, 381⁹ (1929).
- 12. Buza, D., Gryff-Keller, A. and Szymanski, S., Roczniki Chem., 45, 549 (1971); Chem. Abstr., 75, 98071^V (1971).
- 13. Dippy, J.F.J., McGhie, J.F. and Young, J.T., Chem. and Ind. (London), 195 (1952).
- 14. Hahn, L.V. and Miquel, J.F., Compt. Rend., 257, 1948 (1963).
- 15. Kuhn, L.P., Lutz, R.E. and Bauer, C.R., J. Am. Chem. Soc., 72, 5058 (1950).
- 16. Black, W.B. and Lutz, R.E., J. Am. Chem. Soc., <u>75</u>, 5990 (1953).
- 17. Trummer, I., Magyar Tudományos Akad. Központi Fiz. Kutato Intézetének Közleményei, <u>4</u>, 481 (1956); <u>5</u>, 3, 130 (1957); Chem. Abstr., <u>55</u>, 17207^b (1961).
- 18. Noyce, D.S. and Jorgenson, M.J., J. Am. Chem. Soc., <u>83</u>, 2525 (1961).

- 19. Noyce, D.S. and Jorgensen, M.J., J. Am. Chem. Soc., <u>85</u>, 2420 (1963).
- 20. Friedrich, L.E. and Cormier, R.A., J. Org. Chem., <u>35</u>, 450 (1970).
- 21. Mitina, V.G., Zadorozhnyi, B.A. and Lavrushin, V.F., Zh. Obshch. Khim., 45, 2713 (1975).
- 22. Eneback, C. and Gripenberg, J., Acta Chem. Scand., 11, 866 (1957).
- 23. Davey, W. and Guilt, J.R., J. Chem. Soc., 1017 (1957).
- 24. Heilbron, I.M. and Wilson, F.J., Proc. Chem. Soc., <u>27</u>, 315; J. Chem. Soc., <u>101</u>, 1482 (1912).
- 25. Heilbron, I.M. and Wilson, F.J., J. Chem. Soc., <u>103</u>, 1504 (1913).
- 26. Bu-Hoi, N.P. and Michel, S., Bull. Soc. Chim. France, 219 (1958).
- 27. Gheorghiu, C.V. and Avramovici, S., Analele Stiint. Univ.

  "Al. I. Cuza" Iasi, Sect. I [N.S.], 3, 381 (1957); Chem.

  Abstr., 53, 15059^c (1959).
- 28. Avramovici, S., Gabe, I. and Zugravescu, I., Rev. Roumaine Chim., <u>10</u>, 471 (1965); Studii Cercetari Chim., <u>14</u>, 453 (1965); Chem. Abstr., <u>63</u>, 11317^f (1965).
- 29. McVeigh, J.L. and Rose, J.D., J. Chem. Soc., 713 (1945).
- 30. Sah, P.P.T. and Chiang, S-H., J. Chinese Chem. Soc., <u>4</u>, 496 (1936); Chem. Abstr., <u>31</u>, 4266 (1937).

# CHAPTER - 13.2

#### STEREOCHEMISTRY OF CHALCONES AND CHALCONE ANALOGUES

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# Introduction:

The conformational features of several chalcones have been arrived at by taking recourse to physical methods. The experimental methods for such investigations include, for example, X-ray crystallography, 1-8 dipole moment determination, 9-29

27

infrared spectroscopy, to nuclear magnetic resonance spectroscopy etc. Only the former two methods are detailed in this chapter.

# X-ray Crystallographic Studies on Unsubstituted

## Chalcone:

Crystal and molecular structure studies based on X-ray crystallographic data are reported for unsubstituted chalcone. It consists of two essentially planar units, which are linked by a non-planar cisoid 1,3-enone bridge twisted about the C-C bond by 16.9°. The assignment of the cisoid conformation

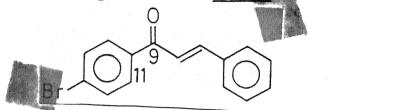
to chalcone finds additional support by the measurement of its molar Kerr constant.²

# Polymorphic Forms of Chalcone:

The conformational details about the polymorphic form of chalcone (m.p. 56°) have been worked out³ and compared with other polymorphic form (m.p. 59°).

## 4'-Bromochalcone:

4'-Bromochalcone possesses a cisoid conformation,



and there exists a large bond twist  $(26^{\circ})$  about  $C_{(9)} - C_{(11)}$  and the two phenyl rings are situated at an angle of  $50^{\circ}$  with respect to each other.⁴

## 4-Methoxychalcone:

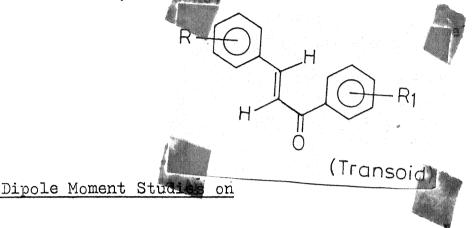
X-ray crystallographic studies⁵ in respect of 4-methoxy-chalcone indicate that the molecule consists of three planar units, viz., methoxyphenyl, enone and phenyl, and the angle between the planar units being 4.5° and 11.5°. A theoretical discussion has been published⁶ concerning the conformation of 4 and 4'-substituted chalcones.

# 4,4'-Dimethylchalcone:

X-ray studies carried on 4,4'-dimethylchalcone⁷ reveal that the angle between the planes of the two phenyl rings is 48.6°, which represents a considerable deviation from planarity. This molecular conformation, it is claimed,⁷ controls the formation of optically active dibromides in the bromination of a single crystal of 4,4'-dimethylchalcone.

## Halonitrochalcones:

Transoid conformations are reported⁸ to exist in the case of 3-chloro-, 3-bromo- and 4-bromo-2'-nitrochalcones.



## Chalcones:

Dipole moments of a large number of chalcones 9-11 and their heterocyclic analogues 12-18 have been determined (cf. Table 1). These data have provided useful information regarding the stereochemistry of these molecules. From dipole moment measurement on chalcone for example, it has been established 19 that the double bond has a trans configuration, and the carbonyl group has a S-cis conformation with respect to the adjoining carbon-carbon double bond.

# Polymorphic Forms of Chalcone:

It has been reported²⁰ that the three polymorphic forms of chalcone (m.p. 59°, 57° and 49° respectively) have the same dipole moment.

## Bromochalcones:

Dipole moment determination of various bromochalcones,  9  viz., 4'-bromochalcone, 4,4'-dibromochalcone,  $\checkmark$ ,  $\beta$ -dibromochalcone,  $\checkmark$ - and  $\beta$ -bromochalcones have been helpful in deciding whether the polar substituents are on the same or opposite sides of double bond of the chalcone molecule.

# Substitution Effects on Dipole Moment of Chalcones and Their Heterocyclic Analogues:

The effect of substituents on dipole moment of chalcone has been studied. 21 Based on the dipole moment data, the electron transfer through the carbonyl group of 4- and 4'-substituted hydroxychalcones has been determined. 22 With chalcone and 4-substituted chalcones (viz., chloro-, bromo-, nitro- and methoxy) there is no interaction with the \$\pi\$-electron system of the phenyl ring (bearing the substituent) with the carbonyl group. In the case of 4,4-dimethylamino-chalcone, however, there seems to be a direct polar conjugation between the carbonyl function and the dimethylamino group.

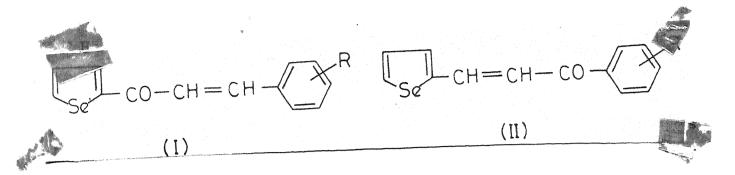
Enough data are available on the dipole moment of 4-and 4'-monosubstituted chalcone, ¹³ furan, ^{12,16,23,24} thiophene, ^{12,25} nitrothiophene, ²⁶ selenophene, ^{12,15} pyrrole ¹⁴ and pyridine ²³ analogues of chalcone. The stereochemical implications of these data are summarized below:

Polarization caused by a heterocyclic ring is greater than that of phenyl and that the observed dipole moment is generally greater than the calculated value. Similar type of difference have been observed in respect of 4- and 4'-monosubstituted chalcones, and have been ascribed 13 to the conjugation of the molecule.

The following conclusions 14 have been drawn in respect of pyrrole analogues of chalcone:

- (a) All these compounds exist in trans form.
- (b) The carbonyl and the vinyl groups assume a  $\underline{S-cis}$  conformation.
- (c) The <u>S-cis</u> conformation can exist in two rotational isomers, viz., <u>syn</u> and <u>anti</u>. In the former the NH of the pyrrole and the carbonyl group lie on the same side of the molecule, while in the latter case, these lie on the opposite sides. The <u>syn-configuration</u> predominates owing to the stability arising due to the weak hydrogen bonding between the NH of pyrrole ring and the adjacent carbonyl group. In some of these compounds, however, the <u>anti</u> configuration is preferred, for example, 1-(2-pyrryl)-3-arylprop-3-ones and 1-(N-methyl-2-pyrryl)-3-phenyl-1-one. The <u>syn-anti</u> conformation is, however, preferred in the case of 1,3-di(2-pyrryl) propenone. 14

The selenophene analogues of chalcone of the type I and II are reported ¹⁵ to exist as mixtures of equal amounts of <a href="syn-S-cis">syn-S-cis</a> and <a href="anti-S-cis">anti-S-cis</a> conformers.



Similar work is reported in respect of the substituted chalcones of the furan  16,23,24  series. The pyridine analogue, however, is reported  23  to exist in a <u>transoid</u> conformation.

Dipole moment data have been used 10 to establish the configuration of the -substituted, viz., -(phenylthio)- and -(phenylsulphonyl)-chalcones. Herein the benzoyl group is ais to the phenyl and trans to the hydrogen atom.

## Erythro-Chalcone Dihalides:

The infrared carbonyl absorption data for <u>erythro</u> chalcone dihalides have been used ²⁷ for calculating the dipole moment of these compounds.

## Chalcone Epoxides:

The dipole moment data of chalcone epoxides are available in the literature. These compounds are reported to exist in gauche conformation. The oxides of the thiophene chalcone analogues exist in S-cis and S-trans conformations, these differing in the mutual orientation of oxirane ring and carbonyl group.

# Huckel Molecular Orbital Calculations:

Based on the Huckel molecular orbital calculations, the  $\frac{\text{trans}}{\text{trans}}$  structure and  $\frac{\text{S-cis}}{31}$  stereochemistry of 2'-hydroxychalcones have been confirmed.

Table 1

Dipole moment of chalcones

Compound	Dipole moment (D)	Ref.
Chalcone	2,92,2,97,3.03,3.04	9,13,16,32
4'-Chlorochalcone	2.98	13
4'-Bromochalcone	2.93	9
4'-Methoxychalcone	3.36	13
4'-Methylchalcone	3.19	13
4'-Nitrochalcone	4.21	13
4'-Phenylchalcone	3.12	13
4-Fluorochalcone	2.61	13
4-Chlorochalcone	2.54,2.74	13,32
4-Chloro-4'-methoxychalcone	3.62	33
4-Chloro-2',4'-dimethoxychalcone	4.09	33
4-Bromochalcone	2.47	9
4,4'-Dibromochalcone	2.03	9
∠-Bromochalcone	<b>3.</b> 87	9
$\beta$ -Bromochalcone	3.59	9
4-Methoxychalcone	3.43,3.40	15,32

4,4'-Dimethoxychalcone	3.65	33
2',4,4'-Trimethoxychalcone	4.08	33
4'-Chloro-4-methoxychalcone	4.05	33
4'-Methyl-4-methoxychalcone	3.85	33.
4'-Nitro-4-methoxychalcone	5.54	33
4'-Phenyl-4-methoxychalcone	3.83	33
4'-Chloro-2,4-dimethoxychalcone	4.85	33
2,4,4'-Trimethoxychalcone	4.31	33
4'-Methyl-2,4-dimethoxychalcone	4.29	33
4'-Nitro-2,4-dimethoxychalcone	7.04	33·
4'-Phenyl-2,4-dimethoxychalcone	4.40	33
4-Methylchalcone	3.26	13
4'-Methoxy-4-methylchalcone	3.88	33
2',4'-Dimethoxy-4-methylchalcone	4.24	33
4-Nitrochalcone	3.6,3.92	13,32
4'-Methoxy-4-nitrochalcone	4.61	33
4,4-Dimethylaminochalcone	4.88	13
4-Phenylchalcone	3.03	13
4'-Methoxy-4-phenylchalcone	3.65	33
2',4'-Dimethoxy-4-phenylchalcone	4.32	33

$$\gamma \beta \propto X - CO - CH = CH - Y$$

$\gamma$ -Keto- $\gamma$ (2-furanyl)- $\chi$ -phenyl-1-propene	3.19	16
Y-Keto-Y(5-nitro-2-furanyl)- ∠-phenyl-1-propene	2.96	16
√-Keto-√(2-furanyl)- <-(4- methoxyphenyl)-1-propene	3.59	16
√-Keto- √(5-nitro-2-furanyl)- ∠ -(4-methoxyphenyl)-1- propene	3.63	16
Y-Keto-√(2-furanyl)-∠(2,4- dimethoxyphenyl)-1-propene	4.18	16
√-Keto-√(5-nitro-2-furanyl)- (2,4-dimethoxyphenyl)≪- 1-propene	4.40	16
√-Keto- √(2-furanyl)-≪-(4- nitrophenyl)-1-propene	4.43	16
√-Keto- √-phenyl-∠(2-furanyl) -1-propene	3.03	16
√-Keto-√(4-methoxyphenyl)- <(2- furanyl)-1-propene	3.22	16
Y-Keto- $\Upsilon$ (2,4-Dimethoxyphenyl) - $\chi$ (2-furanyl)-1-propene	3.90	16
√-Keto- √(4-nitrophenyl)-≪(2- furanyl)-1-propene	4.97	16
√-Keto- √-phenyl-∠(5-nitro-2- furanyl)-1-propene	2.91	16
√-Keto- √ (4-methoxyphenyl)- √ (5-nitro-2-furanyl)-1- propene	3.23	16
γ-Keto-γ(2,4-dimethoxyphenyl) χ- (5-nitro-2-furanyl)-1- propene	5.17	16
Y-Keto-Y (4-nitrophenyl)-≺ (5- nitro-2-furanyl)-1-propene	4.86	16
1-Keto-0, Y-di(2-furanyl)-1- propene	<b>3.1</b> 7	16

#### References

- 1. Rabinovich, D., J. Chem. Soc., B, 11 (1970).
- 2. Bramley, R. and Le Fevre, R.J.W., J. Chem. Soc., 56 (1962).
- Ohkura, K., Kashino, S. and Haisa, M., Bull. Chem. Soc.
   Japan, 46, 627 (1973).
- 4. Rabinovich, D., Schmidt, G.M.J. and Shakked, Z., J. Chem. Soc. Perkin Trans., 2(1), 33 (1973).
- 5. Rabinovich, D. and Schmidt, G.M.J., J. Chem. Soc., B, 6 (1970).
- 6. Tsukerman, S.V., Surov, Y.N. and Lavrushin, V.F., Zh. Organ. Khim., <u>6</u>, 887 (1970); Chem. Abstr., <u>73</u>, 14315^a (1970).
- 7. Rabinovich, D. and Shakked, Z., Acta Crystallogr., 30B, 2829 (1974).
- 8. Jungk, A.E. and Schmidt, G.M.J., J. Chem. Soc., B, 1427 (1970).
- 9. Bergmann, E., J. Chem. Soc., 402 (1936).
- 10. Baliah, V. and Natarajan, C., Indian J. Chem., 9, 435 (1971).
- 11. Dinya, Z., Litkei, G., Levai, A., Boleskei, H., Jeckel, P., Rochlitz, S., Kiss, A.I., Farkas, M. and Bognar, R., Bioflavonoid Symposium, 5th, pp. 247-55 (1977). Edited by Farkas, L., Gabor, M. and Kalley, F., Elsevier Amsterdam, Netherlands; Chem. Abstracts, 89, 42239^c (1978).
- 12. Tsukerman, S.V., Orlov, V.D., Nikitchenko, V.M., Rozum, Y.S., Lavrushin, V.F. and Yur'ev, Y.K., Teor. i Eksperim. Khim., Akad. Nauk Ukr. SSR, 2, 399 (1966); Chem. Abstr., 65, 16839^h (1966).

- 13. Tsukerman, S.V., Surov, Y.N. and Lavrushin, V.F., Zh.

  Obshch. Khim., 38, 524 (1968); Chem. Abstr., 69, 6536^a

  (1968).
- 14. Tsukerman, S.V., Izvekov, V.P. and Lavrushin, V.F., Zh. Fiz. Khim., 42, 2159 (1968); Chem. Abstr., 70, 57025^m (1969).
- 15. Tsukerman, S.V., Orlov, V.D., Lam Ngok Thiem and Lavrushin, V.F., Khim. Geterotsikl. Soedin., 6, 974 (1969); Chem. Abstr., 73, 7447^S (1970).
- 16. Tsukerman, S.V., Artemenko, A.I. and Lavrushin, V.F., Zh. Obshch. Khim., 34, 3591 (1964); Chem. Abstr., 62, 4736° (1965).
- 17. Tsukerman, S.V., Bugai, A.I., Izvekov, V.P. and Lavrushin, V.F., Khim. Geterotsikl. Soedin., 8, 1083 (1972); Chem. Abstr., 77, 151341° (1972).
- 18. Nikitchenko, V.M., Ibrahim, S. and Lavrushin, V.F., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., <u>15</u>, 720 (1972); Chem. Abstr., <u>77</u>, 87648^d (1972).
- 19. Grunfest, M.G., Kolodyazhnyi, Y.V., Osipov, O.A.,
  Yanovskaya, L.A., Umirzakov, B., Kucherov, V.F. and
  Vorontsova, L.G., Izv. Akad. Nauk SSSR, Ser. Khim., (12),
  2662 (1972); Chem. Abstr., 78, 110356^p (1973).
- 20. Eisenlohr, F. and Metzner, A., Z. Physik. Chem., <u>178A</u>, 350 (1937); Chem. Abstr., <u>31</u>, 4552¹ (1937).
- 21. Yanovskaya, L.A., Umirzakov, B., Kucherov, V.F., Yakovlev, I.P., Zolotarev, B.M., Chizhov, O.S., Vorontsova, L.G.,

- Fundyler, I.N., Grunfest, M.G., Kolodyazhny, Y.V. and Osipov, O.A., Tetrahedron, 29, 4321 (1973).
- 22. Verkhovod, N.N., Verkhovod, V.M., Litvinenko, E.V. and Lavrushin, V.F., Visn. Kharkiv. Univ., Khim., <u>73</u>, 81 (1971); Chem. Abstr., <u>78</u>, 57506^j (1973).
- 23. Orlov, V.D., Tsukerman, S.V. and Lavrushin, V.F., Vop. Stereokhim. No. 1, 89 (1971); Chem. Abstr., 77, 151343⁶ (1972).
- 24. Andrieu, C. and Lumbroso, H., C. R. Acad. Sci., Ser. C., (13), 272 (1971).
- 25. Lavrushin, V.F., Verkhovod, V.M., Roberman, A.I. and Ostrovskaya, B.I., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., 18, 1707 (1975); Chem. Abstr., 84, 73485 (1976).
- 26. Verkhovod, V.M., Khashchina, M.V., Berestetskaya, V.D. and Lavrushin, V.F., J. Structural Chem., 18, 26 (1977).
- 27. Weber, F.G. and Westphal, G., Z. Chem., 15, 215 (1975).
- 28. Orlov, V.D., Korotkov, S.A., Tishchenko, V.N. and Lavrushin, V.F., Zh. Strukt. Khim., <u>14</u>, 567 (1973); Chem. Abstr., <u>79</u>, 65590^t (1973).
- 29. Yanovskaya, L.A., Dombrovskii, V.A., Kucherov, V.F., Grunfest, M.G., Kolodyazhnyi, Y.V. and Osipov, O.A., Izv. Akad. Nauk SSSR, Ser. Khim., (9), 2144 (1973); Chem. Abstr., 80, 59277^a (1974).
- 30. Arbuzov, B.A., Vul'fson, S.G., Donskova, A.I. and Vereshchagin, A.N., Bull. Acad. Sciences, U.S.S.R., 25, 1443 (1977).

- 31. Grouiller, A., Thomassery, P., Pacheco, H., Decoret, C. and Tinland, B., Bull. Soc. Chim. France, 12, 3454 (1973).
- 32. Mauret, P., Mermillod-Blardet, D. and Maroni, P., Bull. Soc. Chim. France, (3), 903 (1971).
- 33. Lavrushin, V.F., Verkhovod, N.N., Verkhovod, V.M. and Litvinenko, E.V., Zh. Obshch. Khim., 40, 1343 (1970).

# CHAPTER - 14

# SPECTROSCOPIC STUDIES OF CHALCONES AND THEIR DERIVATIVES

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#### ULTRAVIOLET SPECTROSCOPY

## Introduction:

Trans-chalcone usually shows two absorption bands located at 300 nm (Band I) and 230 nm (Band II) respectively. Previously these bands were believed to originate due to the presence of two chromophoric groups, viz., benzoyl and cinnamoyl moieties, in the chalcone molecule. According to the accepted view, band I arises due to the conjugation of the relation at whole, thus:

$$\begin{array}{c}
B \\
B \\
CH = CH - C = C \\
B \\
CH - C = C - A \\
CH - C = C - A
\end{array}$$

The third band ... 207 mm has also been reported and has been characterised as the modified E-band of the phenyl group.

Another band located between 250-270 nm (middle band) has been observed in cis-chalcones, 2,3,5-8 as well as in some transisomers. 1 It has been reported that the U.V. spectrum of cis-chalcone contains styrene absorption bands which are absent in the spectrum of trans-chalcone.

The electronic absorption spectra have been calculated for chalcone, 10 its derivatives, 11 and the heterocyclic analogues

of chalcone.¹² On the basis of theoretical calculations it has been shown¹³ that the long wave ultraviolet absorption bands of 4-substituted chalcones are more complex in nature. There exist other bands besides those arising due to intramolecular charge transfer transition.

# Substituent Effects on U.V. Absorption of Chalcones 4, 14-17:

In general, substitution in ring B causes greater bathochromic shift of band I, than in ring A.^{4,14,15} Electron withdrawing substituents in ring B produce large hypsochromic effect.¹⁶ but when present in ring A they exhibit bathochromic effects.

Replacement of the phenyl moiety (ring A or ring B) with 2-thienyl or 2-furyl gives rise to a bathochromic shift of band I.^{3,18,19} The effect, however, is more pronounced when the phenyl group (ring B) is substituted by the heterocyclic residue.¹⁹

## Solvent Effect:

The effect of solvent on the position of  $n-\pi^*$  and  $\pi-\pi^*$  transition in chalcone derivatives has been studied.²⁰

# Miscellaneous Studies:

The ultraviolet absorption studies are reported for the following compounds: chalcones, 1-3,8,10,13,15,21-57 heterocyclic analogues of chalcone, 16,19,58-69 chalcone glucosides, 70

chalcone complexes with boron trifluoride, ⁷¹ ferric chloride, ^{37,72} antimony pentachloride ⁷² and boric acid, ⁴¹ chalcone-2,4-dinitrophenyl-hydrazones ⁷³⁻⁷⁶ and chalcols. ⁷⁷

## INFRARED SPECTROSCOPY

Several studies in respect of infrared absorption of chalcones, ⁷⁸⁻⁸⁶ heterocyclic analogues of chalcones ^{9,87-91} and chalcone derivatives ⁹² have been published.

## Carbonyl Group, Substituent Effects:

The integral intensities of carbonyl absorption band in the infrared spectra of chalcone, 4- and 4'-substituted chalcones, as well as heterocyclic analogues (selenienyl, thienyl and furyl) have been reported. 93

The frequency of carbonyl absorption in chalcone has been determined by 'Huckel's Molecular Orbital Method' as well as on the basis of other theoretical calculations. 94

The substituent effects on the carbonyl stretching frequency of chalcone 95-98 and its heterocyclic analogues 90,93 have been published.

# Hydrogen Bonding:

The effect of hydrogen bonding, viz., intermolecular and intramolecular type, on the carbonyl group of hydroxychalcones have been described in the literature. 96,99,100

The intramolecular hydrogen bonding in respect of <u>cis</u>- and <u>trans</u>-isomers of 2'-hydroxy-3'-nitrochalcone has been studied. 101 In the <u>cis</u>-isomer, the hydroxyl and the nitro groups are hydrogen bonded, while in the <u>trans</u>-isomer the 2'-hydroxyl group is chelated with the carbonyl group. 101

In the case of 2'-hydroxychalcone, the hydrogen bond energy has been calculated. 95

## Basicity:

Infrared absorption data has been used for comparison of relative basicities of chalcones, 102-104 ferrocene 105 and thiophene 106 analogues of chalcone.

## Rotational Isomers:

Infrared spectroscopy has been employed in studying the rotational isomers (S-cis and S-trans) of substituted chalcones 107-117 and heterocyclic analogues of chalcone. 105,118

# Raman Spectroscopy:

The Raman spectrum of chalcone has been reported 119-121 in the literature.

## NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

## Chalcones and Their Heterocyclic Analogues:

The proton magnetic resonance spectra of some chalcones ¹²² and their heterocyclic analogues (containing furan, thiophene and selenophene ring attached at 2-position) are reported ¹²³ in the literature.

The correlation between the N.M.R. signals of the hydroxyl groups of chalcone derivatives (in acetone solvent) and the 5-substituent parameters have been reported. 124

as well as those of heterocyclic analogues of chalcone 126 are wellas those of heterocyclic analogues of chalcone 126 are available in the literature. C/and PMR spectra have been studied 127 for ferrocenyl chalcone and their iron carbonyl complexes. It has been stated that the conjugation in the chalcone molecule is reduced by its coordination with the iron carbonyl. Based on 13C-N.M.R. data, the effect of the ferrocenyl group on the T-electron distribution in chalcone, has been studied. 128

## Chalcone Derivatives:

From the examination of N.M.R. spectra of some substituted chalcone epoxides, the following conclusions have been drawn. 129

The epoxide ring has a <u>trans</u> configuration and the two oxirane ring protons appear in the range 5.70-5.82 T and 5.82-6.02 T respectively.

N.M.R. data^{92,130} are available for isocyanato-halochalcones, trans-chalcone-oxime, semicarbazone, thiosemicarbazone 3,5-diphenyl-1-acetamido (and thioacetamido)-2-pyrazolines.

## MASS SPECTROMETRY

#### Chalcones:

The mass spectrum of charcone shows three favoured ions, viz., M⁺, (M-1)⁺ and (M-29)⁺, where M⁺ stands for the molecular ion. The following mechanism¹³¹ has been advanced to explain the fragmentation process:

The first step is the loss of hydrogen, since it permits the formation of an extra bond. This is followed by the loss of carbon monoxide leading to the fused ring structure (vide supra).

Skeletal rearrangements occur in the mass spectrometry of chalcone. The following rearrangement ions are reported, ¹³² with their relative abundance (expressed as %).

$$C_{13}H_{9}^{+}$$
 (11);  $C_{14}H_{10}^{+}$  (13) and  $C_{14}H_{11}^{+}$  (26)

It has been shown 133,134 that electron bombardment of 2'-hydroxychalcone leads to the formation of flavanone. The mechanism 133 involves the migration of the phenolic hydrogen to

illustrated 135:

OH 
$$\phi$$
 $OH \phi$ 
 Based on mass spectrometric data, ionization potential of 4- and 4'-monosubstituted chalcones have been determined. The values so obtained are reported 136 to be in agreement with the values arrived at by molecular orbital calculations.

## Chalcone Epoxides:

Mass spectrometry has been utilized 137 for the qualitative characterization of the transmission effects through the oxirane ring of chalcone epoxide.

## References

- 1. Wheeler, O.H., Gore, P.H., Santiago, M. and Baez, R., Can. J. Chem., 42, 2580 (1964).
- 2. Katzenellenbogen, E.R. and Branch, G.E.K., J. Am. Chem. Soc., <u>69</u>, 1615 (1947).
- 3. Szamant, H.H. and Basso, A.J., J. Am. Chem. Soc., <u>74</u>, 4397 (1952).
- 4. Klinke, P. and Gibian, H., Chem. Ber., 94, 26 (1961).
- 5. Lutz, R.E. and Jordan, R.H., J. Am. Chem. Soc., <u>72</u>, 4090 (1950).
- 6. Lutz, R.E., Hinkley, D.F. and Jordan, R.H., J. Am. Chem. Soc., 73, 4647 (1951).
- 7. Black, W.B. and Lutz, R.E., J. Am. Chem. Soc., <u>75</u>, 5990 (1953).
- 8. Black, W.B. and Lutz, R.E., J. Am. Chem. Soc., 77, 5134

- 9. Mitina, V.G., Sukhorukov, A.A., Zadorozhnyi, B.A. and Lavrushin, V.F., Zh. Obshch. Khim., 46, 699 (1976).
- 10. Sukhorukov, A.A., Zadorozhnyi, B.A. and Lavrushin, V.F., Teor. Eksp. Khim., <u>6</u>, 602 (1970); Chem. Abstr., <u>74</u>, 93047^m (1971).
- 11. Leska, J. and Zahradnik, P., Acta Fac. Rerum Natur. Univ. Comenianae, Chim., No. 18, 43 (1973); Chem. Abstr., <u>84</u>, 73422^h (1976).
- 12. Reinhardt, M., Sukhorukov, A.A., Raushal, A. and Lavrushin, V.F., Khim. Geterotsiki Soedin (9), 1202 (1977); Chem. Abstr., 88, 5753^Z (1978).
- 13. Fundyler, I.N. and Ryaboi, V.M., Izv. Akad. Nauk SSSR, Ser. Khim., (3), 573 (1974); Chem. Abstr., <u>81</u>, 43343^d (1974).
- 14. Shibata, Y.A. and Nagai, W., Acta Phytochim., 2, 25; Chem. Abstr., 19, 3064⁴ (1925).
- 15. Shibata, Y.A. and Nagai, W., J. Chem. Soc. Japan, <u>43</u>, 101 (1922); Chem. Abstr., <u>16</u>, 2512⁹ (1922).
- 16. Coleman, L.E., J. Org. Chem., 21, 1193 (1956).
- 17. David, F.R., Szabo, G.B., Rakosi, M. and Litkei, G., Acta Chim. Acad. Sci. Hung., 94, 57 (1977).
- 18. Szmant, H.H. and Basso, A.J., J. Am. Chem. Soc., <u>73</u>, 4521 (1951).
- 19. Szmant, H.H. and Planinsek, H.J., J. Am. Chem. Soc., <u>76</u>, 1193 (1954).
- 20. Verkhovod, V.M., Verkhovod, N.N., Tolmachev, V.N. and Lavrushin, V.F., Visn. Kharkiv. Univ. Khim., <u>73</u>, 77 (1971); Chem. Abstr., <u>78</u>, 57244^x (1973).

- 21. Stobbe, H. and Ebert, E., Chem. Ber., 44, 1289 (1911).
- 22. Russell, A., Todd, J. and Wilson, C.L., J. Chem. Soc., 1940 (1934).
- 23. Alexa, V., Bul. Soc. Chim. Romania, <u>18A</u>, 93 (1936); Chem. Abstr., <u>31</u>, 3387⁴ (1937).
- 24. Cromwell, N.H. and Johnson, R.S., J. Am. Chem. Soc., <u>65</u>, 316 (1943).
- 25. Ferguson, L.N. and Barnes, R.P., J. Am. Chem. Soc., <u>70</u>, 3907 (1948).
- 26. Cromwell, N.H. and Watson, W.R., J. Org. Chem., <u>14</u>, 411 (1949).
- 27. Thomas, J.F. and Branch, G., J. Am. Chem. Soc., <u>75</u>, 4793 (1953).
- 28. Black, W.B., Dissertation Abstr., 14, 1532 (1954).
- 29. Browne, C.L. and Lutz, R.E., J. Org. Chem., 18, 1638 (1953).
- 30. Wiley, R.H., Jarboe, C.H. (Jr.) and Ellert, H.G., J. Am. Chem. Soc., 77, 5102 (1955).
- 31. Grammaticakis, P. and Chauvelier, J. Compt. Rend., <u>242</u>, 1189 (1956).
- 32. Walker, E.A. and Young, J.R., J. Chem. Soc., 2041 (1957).
- 33. Hassner, A. and Cromwell, N.H., J. Am. Chem. Soc., <u>80</u>, 893 (1958).
- 34. Haske, B.J., Dissertation Abstr., 20, 1168 (1959).
- 35. House, H.O. and Ryerson, G.D., J. Am. Chem. Soc., <u>83</u>, 979 (1961).

- 36. Hahn, L.V. and Miquel, J.F., Compt. Rend., <u>257</u>, 1948 (1963).
- 37. Lavrushin, V.F., Dzyuba, V.P. and Tolmachov, V.M., Zh. Obshch. Khim., 35, 95 (1965).
- 38. Sinyagovskaya, L.A., Lavrushin, V.F. and Tolmachov, V.M., Zh. Obshch. Khim., 35, 1929 (1965).
- 39. Bondarenko, V.E., Dashevskii, M.M., Krasovitskii, B.M. and Pereyaslova, D.G., Zh. Organ. Khim., 2, 1060 (1966).
- 40. Mahanta, B.C., Nayak, P.L. and Rout, M.K., J. Inst. Chem. (India), <u>42</u>, 49 (1970); Chem. Abstr., <u>73</u>, 55239^x (1970).
- 41. Hörhammer, L. and Hänsel, R., Arch. Pharm., <u>288</u>, 315 (1955); Chem. Abstr., <u>51</u>, 6619^h (1957).
- 42. Wittman, H., Uragg, H. and Stark, H., Monatsh. Chem., <u>97</u>, 896 (1966).
- 43. Λkaboshi, S. and Kutsuma, T., Yakugaku Zasshi, <u>89</u>, 375 (1969); Chem. Λbstr., <u>71</u>, 29883^S (1969).
- 44. Nikitina, Λ.N., Fedyunina, G.M., Umirzakov, B., Yanovskaya, L.Λ. and Kucherov, V.F., Opt. Spektrosk., <u>34</u>, 289 (1973); Chem. Abstr., <u>78</u>, 158500^h (1973).
- 45. Alexa, V., Bul. Chim., Soc. Chim. Romania [2], 1, 77 (1939); Chem. Abstr., 37, 3668⁴ (1943).
- 46. Lin, C-H., Su, J-T. and Chen, F-C., Tai-wan Ke Hsueh, <u>17</u>, 29 (1963); Chem. Abstr., <u>60</u>, 7896^c (1964).
- 47. Ristic, S. and Baranac, J.M., Proc. Colloq. Spectrosc.
  Int. 14th, <u>3</u>, 1219 (1967); Chem. Abstr., <u>73</u>, 93177^h (1970).
- 48. Dzurilla, M., Kristian, P. and Gyoryova, K., Chem. Zvesti., 24, 207 (1970); Chem. Abstr., 74, 53196° (1971).

- 49. Dhar, D.N. and Singhal, D.V., Spectrochim. Acta, <u>26A</u>, 1171 (1970).
- 50. Patel, D.R. and Patel, S.R., J. Indian Chem. Soc., <u>45</u>, 703 (1968).
- 51. Cavina, G., Rend. ist. super. sanita, <u>16</u>, 154 (1953); Chem. Abstr., 48, 8651 (1954).
- 52. Polansky, O., Monatsh. Chem., 88, 91 (1957).
- 53. Baliah, V. and Shanmuganathan, S., J. Phys. Chem., <u>62</u>, 255 (1958).
- 54. Orlov, V.D., Borovoi, I.A. and Lavrushin, V.F., Zh. Obshch. Khim., 43, 642 (1973).
- 55. Dhar, D.N. and Singh, R.K., J. Indian Chem. Soc., <u>50</u>, 129 (1973).
- 56. Dhar, D.N. and Singh, R.K., J. Indian Chem. Soc., <u>49</u>, 241 (1972).
- 57. Dolter, R.J. and Columba, C., J. Am. Chem. Soc., <u>82</u>, 4153 (1960).
- 58. Lavrushin, V.F., Tsukerman, S.V. and Nikitchenko, V.M., Zh. Obshch. Khim., 32, 2677 (1962).
- 59. Lavrushin, V.F., Tsukerman, S.V. and Artemenko, A.I., Zh. Obshch. Khim., 32, 2551 (1962).
- 60. Tsukerman, S.V., Artemenko, A.I. and Lavrushin, V.F., Zh. Obshch. Khim., 33, 3528 (1963).
- 61. Egger, H. and Schloegl, K., J. Organometal. Chem., 2, 398 (1964).

- 62. Trusevich, N.D., Kanate, B., Nikitchenko, V.M. and
  Lavrushin, V.F., Dopov. Akad. Nauk. Ukr. RSR, Ser. B <u>36</u>,
  454 (1974); Chem. Abstr., 81, 62911^d (1974).
- 63. Mitina, V.G., Zadorozhnyi, B.A. and Lavrushin, V.F., Teor. Eksp. Khim., 9, 263 (1973); Chem. Abstr., 79, 25244^b (1973).
- 64. Tsukerman, S.V., Ch'ang, K-S. and Lavrushin, V.F., Khim. Geterotsikl. Soedin., Akad. Nauk Latv. SSR (4), 537 (1965); Chem. Abstr., 64, 559^g (1966).
- 65. Tsukerman, S.V., Ch'ang, K-S. and Lavrushin, V.F., Zh.

  Prikl. Spectroskopii, Akad. Nauk Belorussk. SSR, 4 (6), 554

  (1966); Chem. Abstr., 65, 14660° (1966).
- 66. Lavrushin, V.F., Verkhovod, V.M., Pristupa, V.K. and Buryakovskaya, E.G., Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., 18, 1504 (1975); Chem. Abstr., 84, 23912^x (1976).
- 67. Tsukerman, S.V., Nikitchenko, V.M. and Lavrushin, V.F., Zh. Obshch. Khim., 33, 1255 (1963).
- 68. Tsukerman, S.V., Orlov, V.D. and Lavrushin, V.F., Khim. Str., Svoistva Reaktivnost Org. Soedin., 63 (1969); Chem. Abstr., 72, 99698 (1970).
- 69. Roshka, V.K., Tezisy Dokl. Soobshch.-Konf. Molodykh Uch. Mold., 9th (1974). (Pub. 1975), 106. Edited by Lazarev, A.M., "Shtiintsa": Kishinev USSR; Chem. Abstr., <u>84</u>, 179102^u (1976).
- 70. Rakosi-David, E., Bognar, R. and Tokes, A., Acta Phys. Chim., Debrecina, 14, 145 (1968); Chem. Abstr., 71, 61713 (1969).

- 71. Surov, Y.N., Shkumat, H.P., Nikitchenko, V.M., Tsukerman, S.V. and Lavrushin, V.F., Zh. Obshch. Khim., 48, 2291 (1978).
- 72. Tolmachev, V.N., Boberov, O.F. and Lavrushin, V.F., Dopov. Akad. Nauk Ukr. RSR, (11), 1454 (1966); Chem. Abstr., <u>66</u>, 60470^a (1967).
- 73. Rappoport, Z. and Sheradsky, T., J. Chem. Soc., B, 898 (1967).
- 74. Roberts, J.D. and Green, C., J. Am. Chem. Soc., <u>68</u>, 214 (1946).
- 75. Johnson, G.D., J. Am. Chem. Soc., 75, 2720 (1953).
- 76. Yaroslavsky, S., J. Org. Chem., <u>25</u>, 480 (1960).
- 77. Lavrushin, V.F., Grin, L.M., Pivnenko, N.S. and Kutsenko, L.M., Ukr. Khim. Zh., <u>38</u>, 798 (1972); Chem. Abstr., <u>78</u>, 3416^m (1973).
- 78. Lecomte, J. and Guy, J., Compt. Rend., 227, 54 (1948).
- 79. Scrocco, M. and Liberti, A., Ricerca Sci., <u>24</u>, 1687 (1954); Chem. Abstr., <u>49</u>, 7979^f (1955).
- 80. Kovalev, I.P. and Titov, E.V., Zh. Obshch. Khim., <u>33</u>, 1670 (1963).
- 81. Sabata, B.K. and Rout, M.K., J. Indian Chem. Soc., <u>41</u>, 74 (1964).
- 82. Mahanthy, P., Panda, S.P., Sabata, B.K. and Rout, M.K., Indian J. Chem., 3, 121 (1965).
- 83. Trakroo, P.P. and Mukhedkar, A.J., J. Univ. Poona Sci. Technol., <u>28</u>, 101 (1964); Chem. Abstr., <u>64</u>, 160^g (1966).

- 84. Magdeeva, R.K. and Belotsvetov, A.V., Izv. Vyssh. Ucheb.

  Zaved., Khim. Khim. Tekhnol., <u>13</u>, 794 (1970); Chem. Abstr.,

  <u>73</u>, 103778^W (1970).
- 85. Dhar, D.N. and Gupta, V.P., Indian J. Chem., 9, 818 (1971).
- 86. Zalukaev, L.P., Vorobéva, R.P. and Oleinikova, T.A., Zh. Prikl. Spektrosk., <u>21</u>, 558 (1974); Chem. Δbstr., <u>82</u>, 36867^V (1975).
- 87. Dhar, D.N. and Misra, S.S., J. Indian Chem. Soc., <u>49</u>, 629 (1972).
- 88. Misra, S.S., Monatsh. Chem., 104, 11 (1973).
- 89. Tsukerman, S.V., Orlov, V.D., Rozum, Y.S. and Lavrushin, V.F., Khim. Geterotsikl. Soedin., <u>4</u>, 623 (1969); Chem. Abstr., <u>72</u>, 26674^j (1970).
- 90. Verkhovod, V.M., Khashchina, M.V., Berestetskaya, V.D. and Lavrushin, V.F., J. Structural Chem., 18, 26 (1977).
- 91. Verkohovod, V.M., Roberman, A.I., Ostrovskaya, B.I. and Lavrushin, V.F., Vestn. Kharkov Un-ta (175), 95 (1978); Chem. Abstr., 91, 55781^q (1979).
- 92. Weber, F.G., Holzenger,  $\Lambda$ . and Westphal, G., Z. Chem.,  $\underline{16}$ , 19 (1976).
- 93. Tsukerman, S.V., Surov, Y.N. and Lavrushin, V.F., Zh. Obshch. Khim., 38, 2411 (1968).
- 94. Yamaguchi, M., Hayashi, Y. and Matsukawa, S., Bunseki Kagaku, 10, 1106 (1961); Chem. Abstr., 56, 11086¹ (1962).
- 95. Weber, F.G. and Brosche, K.C., Z. Chem., 15, 187 (1975)

- 96. Hergert, H.L. and Kurth, E.F., J. Am. Chem. Soc., <u>75</u>, 1622 (1953).
- 97. Yanovskaya, L.A., Umirzakov, B., Yakovlev, I.P. and
  Kucherov, V.F., Izv. Akad. Nauk SSSR, Ser. Khim., (12), 2666
  (1972); Chem. Abstr., 78, 110045^m (1973).
- 98. Silver, N.L. and Boykin, D.W. (Jr.), J. Org. Chem., <u>35</u>, 759 (1970).
- 99. Chawla, H.M., Chibber, S.S. and Seshadri, T.R., Current. Sci., 44, 344 (1975); Chem. Abstr., 83, 42509⁸ (1975).
- 100. Arventiev, B., Strat, G., Cascaval, A. and Strat, M., An. Stiint, Univ. Al. I. Cuza, lasi, Sect. 1b <u>23</u>, 71 (1977); Chem. Abstract., 91, 4725 (1979).
- 101. Trakroo, P.P. and Mukhedkar, A.J., J. Indian Chem. Soc., 41, 595 (1964).
- 102. Beaupere, D., Uzan, R. and Doucet, J.P., C. R. Acad. Sci., Ser. C., <u>278</u>, 187 (1974); Chem. Abstr., <u>80</u>, 132283^f (1974).
- 103. Tsukerman, S.V., Surov, Y.N. and Lavrushin, V.F., Zh. Obshch. Khim., 37, 364 (1967).
- 104. Trusevich, N.D., Tolmachev, V.N. and Lavrushin, V.F.,

  Vestn. Kharkov Un-t, Khimiya, <u>127</u>, 98 (1975); Chem. Abstr.,

  84, 134982^q (1976).
- 105. Perjessy, Λ., Chem. Zvesti, <u>23</u>, 441 (1969); Chem. Abstr., <u>72</u>, 37296^p (1970).
- 106. Kanate, B., Trusevich, N.D., Surov, Y.N., Nikitchenko, V.M., Vestn. Kharkov Un-t, Khimiya, <u>127</u>, 113 (1975); Chem. Δbstr., <u>84</u>, 163767^d (1976).

- 107. Grouiller, Λ., Thomassery, P. and Pacheco, H., Bull. Soc. Chim. (France), <u>12</u> (Part 2), 3452 (1973); Chem. Abstr., <u>81</u>, 12960^y (1974).
- 108. Hayes, W.P. and Timmons, C.J., Spectrochim. Acta,  $\underline{24A}$ , 323 (1968).
- 109. Perjessy, A., Chem. Zvesti, <u>23</u>, 905 (1969); Chem. Abstr., <u>74</u>, 47553^a (1971).
- 110. Bellamy, L.J., "Infrared Spectra of Complex Molecules",
  Methuen Ltd., London, 1958.
- 111. Bellamy, L.J., Spectrochim. Acta, <u>16</u>, 30 (1960).
- 112. Tsukerman, S.V., Surov, J.N. and Lavrushin, V.F., Zh. Obshch. Khim., 38, 524 (1968).
- 113. Favorskaya, I.A. and Plekhotkina, M.M., Zh. Organ. Khim., 5, 840 (1969); Chem. Abstr., 71, 38136° (1969).
- 114. Arbuzov, B.A., Yuldasheva, L.K., Anonimova, I.V., Shagidullin, R.R., Chernova, A.V. and Fazliev, D.F., Izv. Akad. Nauk, SSSR, Ser. Khim., (6), 1258 (1969); Chem. Abstr., 71, 80535^g (1969).
- 115. Dzurilla, M. and Kristian, P., Coll. Czech. Chem. Commun., 35, 417 (1969).
- 116. Dzurilla, M., Kristian, P. and Gyoryova, K., Chem. Zvesti, 24, 207 (1970); Chem. Abstr., 74, 53196° (1971).
- 117. Dinya, Z. and Litkei, G., Acta Chim. Acad. Sci. Hung., 75, 161 (1973).
- 118. Tsukerman, S.V., Izvekov, V.P., Rozum, Y.S. and
  Lavrushin, V.F., Khim. Geterotsikl. Soedin., (6), 1011
  (1968); Chem. Abstr., 70, 72307 (1969).

- 119. Kohlrausch, K.W.F. and Pongratz,  $\Lambda$ ., Monatsh. Chem., <u>64</u>, 374 (1934).
- 120. Murti, G.V.L.N. and Seshadri, T.R., Proc. Indian Acad. Sci., 8A, 519 (1938).
- 121. Harrand, M. and Guy, J., Compt. Rend., 226, 480 (1948).
- 122. Mabry, T.J., Markham, K.R. and Thomas, M.B., "The Systematic Identification of Flavonoids", Springer Verlag, New York, Heidelberg, Berlin, pp. 335-339 (1970).
- 123. Tsukerman, S.V., Orlov, V.D., Yatsenko, Λ.I. and Lavrushin, V.F., Teor. Eksp. Khim., <u>6</u>, 67 (1970); Chem. Abstr., 73, 34407^k (1970).
- 124. Grin, L.M., Pivnenko, N.S., Kutsenko, L.M. and Lavrushin, V.F., Zh. Organ. Khim., <u>6</u>, 1904 (1970); Chem. Abstr., <u>73</u>, 135762^c (1970).
- 125. Membery, F. and Doucet, J.P., J. de Chimie Physique, <u>73</u>, 1024 (1977).
- 126. Radeglia, R., Orlov, V.D. and Reinhardt, M., Z. Chem., 17, 377 (1977).
- 127. Nesmeyanov, A.N., Shul'pin, G.B., Fedorov, L.A., Petrovsky, P.V. and Rybinskaya, M.I., J. Organometal. Chem., 69, 429 (1974).
- 128. Holak, F.A., Kawalek, B. and Mirek, J., Bull. Acad. Pol. Sci., Ser., Sci. Chim., <u>26</u>, 449 (1978); Chem. Abstr., <u>89</u>, 214551^S (1978).
- 129. Reichel, L. and Neubauer, A., Z. Chem., 8, 180 (1968).

- 130. Balaban, A.T., Zugravescu, I., Avramovici, S. and Silhan, W., Monatsh. Chem.,  $\underline{101}$ , 704 (1970).
- 131. Beynon, J.H., Lester, G.R. and Williams, A.E., J. Phys. Chem., <u>63</u>, 1861 (1959).
- 132. Bowie, J.H., Grigg, R., Williams, D.H., Lawesson, S.O. and Schroll, G., Chem. Commun., (17), 403 (1965).
- 133. Van De Sande, C., Serum, J.W. and Vandewalle, M., Org. Mass. Spectrom., 6, 1333 (1972).
- 134. Jackson, B., Locksley, H.D., Scheinmann, F. and Wolstenholme, W.A., Tetrahedron Letters, 3049 (1967).
- 135. Itagaki, Y., Kurokawa, T., Sasaki, S., Chang, C-T. and Chen, F-C., Bull. Chem. Soc. Japan, 39, 538 (1966).
- 136. Dinya, Z., Litkei, G., Tamas, J. and Czira, G., Acta Chim. Acad. Sci. Hung., <u>84</u>, 181 (1975); Chem. Abstr., <u>82</u>, 155001^t (1975).
- 137. Chizhov, O.S., Shamshurina, S.A., Zolotarev, B.M.,
  Yanovskaya, L.A. and Umirzakov, B., Izv. Akad. Nauk SSSR,
  Ser. Khim., (6), 1389 (1973); Chem. Abstr., 79, 104471^b
  (1973).

#### CHAPTER - 15

#### CHROMATOGRAPHIC SEPARATION OF CHALCONES FROM OTHER FLAVONOIDS

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## Column Chromatography:

of berberine as a fluorescent adsorbent, has been employed successfully for the separation of chalcone from 4-methoxy-chalcone.

2'-Hydroxychalcone are separable from the corresponding flavanones, e.g., butin from butein, by column chromatography using polyamide² as adsorbent. 2'-Hydroxychalcones are retained by the column, while flavanones are eluted with aqueous methanol. The chalcones, adsorbed on the column, are then eluted with the pure solvent. The separation of 2'-hydroxychalcones from flavanols³ and flavanonols³ have likewise been carried out by polyamide column chromatography.

## Thin Layer Chromatography:

Thin layer chromatography (TLC) on silica gel or polyester film has been used for effecting the separation of chalcones from other flavonoids and alkaloids. Hesperidin methyl chalcone in pharmaceuticals has been isolated on polyamide thin layers and subsequently estimated by fluorometric method (treatment of the chalcone-spot with methanolic aluminium chloride, and the fluorescent spot removed, extracted with a solvent and subjected to spectrophotometric analysis).

A preparative TLC method has been developed for the separation on silica gel, of several hydroxychalcones and their corresponding flavanones, using ligroin-ethylacetate as the developer solvent.

The <u>cis-trans</u> isomers of 2-hydroxy-&-methoxychalcone have been separated on silica gel plates using eluotropic solvent, benzene-methanol (95:5).

 $R_f$  values are reported for a large number of substituted aromatic chalcones,  $^{8-10}$  ferrocene,  11  furyl,  10  thienyl 9 ,  10  and pyrryl 9  analogues of chalcones. The  $R_f$  values have been correlated 8  with the position and nature of the substituents.

## Paper Chromatography:

Chalcones have been separated from other flavonoids by paper chromatography 12-14 using butanol-acetic acid-water (4:1:2.2) as the developer solvent. The spot positions of

chalcones on the chromatogram are revealed either by characteristic fluorescence in the ultraviolet light or by colour reactions.

Paper chromatography of some chalcones 15,16 and their glycosides 15 are reported. These give yellow or orange spots on paper developed with aqueous phenol. 15

Paper chromatography, involving the use of boric acid-sodium acetate impregnated paper, has been utilized ¹⁷ for differentiating o-dihydroxyflavanones from similar flavanones-but lacking in catechol type hydroxylic grouping.

Relation between chromatographic parameters of halogenated chalcones by adsorption and partition chromatographic techniques have been studied. 18

## Ion Exchange Chromatography:

Chalcone is reported 19 to be quantitatively adsorbed on the anion exchange resin (Amberlite IRA-400, in HSO₃ form), provided the passage through the column is long and can be eluted with sodium chloride solution.

#### References

- 1. Brockmann, H. and Volpers, F., Chem. Ber., 82, 95 (1949).
- 2. Neu, R., Nature, 182, 660 (1958).
- 3. Neu, R., Arch. Pharm., <u>293</u>, 169 (1960); Chem. Abstr., <u>55</u>, 24734^c (1961).

- 4. Paris, R.R., Rousselet, R., Paris, M. and Fries, Mrs. J.,
  Ann. Pharm. Franc., <u>23</u>, 473 (1965); Chem. Abstr., <u>64</u>, 6404^d
  (1966).
- Silvestri, S., Pharm. Acta Helv., 45, 390 (1970); Chem.
   Abstr., 73, 102100^g (1970).
- 6. Dhar, D.N., J. Indian Chem. Soc., 49, 309 (1972).
- 7. Pastuska, G., Petrowitz, H.J. and Krueger, R., Fresenius Z. Anal. Chem., 236, 333 (1968).
- 8. Dhar, D.N., Tewari, R.P., Ahuja, A.P. and Tripathi, R.D., J. Proc. Inst. Chem. (India), 43, 198 (1971).
- 9. Dhar, D.N., J. Chromatog., 67, 186 (1972).
- 10. Dhar, D.N. and Misra, S.S., J. Chromatog., 69, 416 (1972).
- 11. Bozak, R.E. and Fukuda, J.H., J. Chromatog., <u>26</u>, 501 (1967).
- 12. Mikhaflov, M.K., Doklady Akad. Nauk SSSR, <u>108</u>, 511 (1956); Chem. Abstr., <u>50</u>, 17342^h (1956).
- 13. Nikonov, G.K., Med. Prom. SSSR, <u>12</u>, 16 (1959); Chem. Abstr., <u>53</u>, 14094^b (1959).
- 14. Curtze, A. and Holland, W., Deut. Apoth.-Ztg., <u>107</u>, 147 (1967); Chem. Abstr., 66, 108283^W (1967).
- 15. Puri, B. and Seshadri, T.R., J. Sci. Ind. Research (India), 12B, 462 (1953).
- 16. Fujise, S. and Tatsuta, H., J. Chem. Soc. Japan, <u>73</u>, 35 (1952).
- 17. Jurd, L., J. Chromatog., 4, 369 (1960).

- 18. Covello, M., Schettino, O., Ferrara, L. and Forgione, P., Rend. Accad. Sci. Fis. Mat., Naples, 41, 290 (1975); Chem. Abstr., 84, 112062ⁿ (1976).
- 19. Sjöström, E., Acta Polytech., <u>144</u>, 7 (1954); Chem. Abstr., <u>49</u>, 1483ⁱ (1955).

PART - IV

## CHAPTER - 16

#### NATURALLY OCCURRING CHALCONES AND THEIR DERIVATIVES

During the past decade a number of reports have appeared in the literature, describing the isolation of chalcones from the various parts of the plants, viz., roots, 6,19,20,24,82,83 heart-wood, 44,73,79,80 buds, 4 leaves, 23,27,29,34,36,51,52,54,58,71 blossoms, 45-47 inflorescences, 33 flowers 2,8,17,18,23,29,42 and seeds. 5,53,57,71,74 These compounds exist in the free state as chalcones or in the combined form as glycosides. The substituent(s), viz., hydroxy, methoxy, methyl and isopentenyl, may be present either in ring A and/or ring B of the chalcone molecule. Besides, there are reports 58,66,70,76,82-85 about the isolation of dihydrochalcones from the higher plants.

Table I lists (<u>vide infra</u>) the naturally occurring chalcones and their derivatives.

Table I

Naturally occurring chalcones and their derivatives

Source	Chalcones and their derivatives Ref.
Acacia	2',3',4',4-Tetrahydroxychalcone 1
auriculiformis	다는 사람이 많은 경기가 하고 있을까지 못했다. 그는 다른 사람들이 되었다. 이 사람들이 하는 사람들이 되었다. 하는 사람들이 나는 사람들이 되었다.
Acacia cyanophylla	Chalcononaringenin-4-glucoside, 2
(Flowers)	Isosalipurposide

Adenanthera pavonina	Chalcone and	
"Red Sandalwood"	2',3,4,4'-Tetrahydroxychalcone	3
	(Butein)	
Alnus virdis (Buds)	4',5'-Dihydroxy-6'-methoxychalcone	4
Alpinia speciosa	2',4'-Dihydroxy-6'-methoxychalcone	5
(Seeds)	(Cardamonin)	
Angelica keiskei	Prenyl chalcones: Xanthoangelol	6
(Roots)  Aniba rosaeodora  DUCKE	and hydroxy derricin  H O OH  H O ST 6  Me T 4 H 3 2 7 CH3  Me H A T T CH3	7
Antirrhinum majus (Yellow flowers)	Chalcononargenin-4'-glucoside, 2',3,4,4',6'-Pentahydroxychalcone- 4'-glucoside	8
Berchemia zeyheri	∠,2',4,4',6'-Pentahydroxychalcone	9

"Red ivory" (Red-wood)

Bidens tripartite	2,3',4,4'-Tetrahydroxychalcone, Butein-7-0- $\beta$ -D-glucopyranoside	10
Chromalaena odorata	2',4-Dihydroxy-4',5',6'- trimethoxychalcone, 2'-Hydroxy- 4,4',5,5',6'-pentamethoxychalcone	11
"Citrus Molasses"	A Methylchalcone	12
Cordoa piaca (Lonchocarpus)	Cordoin, Isocordoin, ♥-Isocordoin, Dihydrocordoin, Derricin, 4-Hydroxy- derricin, Lonchocarpin, 4-Hydroxy- lonchocarpin and 4-Hydroxy- isocordoin	13-16
Coreopsis tinctoria (Ray flowers)	4'-Glucosidoxy-2',3',3,4-tetra- hydroxychalcone (Marein)	17
"Cotton" (Flowers)	2',3',4',6',8',3,4-Heptahydroxy-chalcone glucoside	18
Cryptocarya bourdilloni (Lauraceae) Roots	СО-СH= CH-«	19,20

Daemonorops dracu	2,4-Dihydroxy-5-methyl-6-methoxy	21
"Dragon's blood	chalcone; 2,4-Dihydroxy-6-methoxy-	
resin"	chalcone	
Fruit		
Dahlia species	4'-Arabinosylgalactoside of butein and other glycosides	* 22
Dahlia tenuicaulis	2'-Hydroxy-4,4',6'-trimethoxy-	23
(Leaves)	chalcone	
Dahlia tenuicaulis (Flower heads)	4,2',4'-Trihydroxychalcone, 3,2',4'-Trihydroxy-4-methoxychalcone	23
Datisca cannabina	Unidentified chalcone	24
(Root cortex)		
Derris sericea	OH	25
(Root bark)	$CO-CH=CH-\emptyset$	
	$R = (Me_2C = CH - CH_2 - CH_$	
Didymocarpus	2',6'-Dihydroxy-4',5'-dimethoxy-	26
pendicellata	chalcone	

(Pashanone)

(Gesneriaceae)

Roots

2'-Hydroxy-4,4',5',6'-tetramethoxy-Eupatorium odoratum 27 (Leaves) chalcone Flemingia Chappar 2',4'-Dihydroxychalcone, 28-32 Ham. 2',4',4-Trihydroxychalcone, (Whole plant) 2',4'-Dihydroxy-5'-methoxychalcone Me 4',6'-Dihydroxy-3'-methoxychalcone Flemingia Chappar Ham. (Flower/leaves) Flemingia congesta HO (Inflorescences) (Chromenochalcone

# Flemingia stricta (Leguminoseae) OH (Leaves) HO 3',6'-Dihydroxy-2',4',5',4-Flemingia 35 strobilifera tetramethoxychalcone (Roots) Flemingia wallichii Homoflemingin, 36 (Leaves) Flemiwallichin Glycyrrhiza echinata 4,4'-Dihydroxy-2-methoxychalcone 37 (Tissue culture) (Echinatin) Glycyrrhiza glabra 2,4,4'-Trihydroxychalcone, 4-38,39 (Roots) Hydroxychalcone, Unidentified chalcones, Glycosidal chalcone 40 Glycyrrhiza glabra (Root bark) OMe R

 $R = (CMe_2 - CH = CH_2);$ 

# Gnaphalium affine

(Flowers)

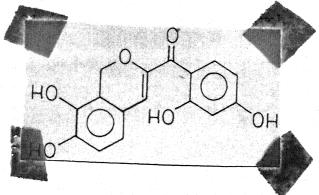
# Gnaphalium multiceps

$$CH_2OH$$
 $OH$ 
 $OH$ 
 $OH$ 
 $OH$ 
 $CO-CH=CH$ 
 $OH$ 

## Goniorrhachis

# marginata

(Heartwood)



# Helichrysum

2',3,4,4',6'-Pentahydroxychalcone-

45-47

## bracteatum

2'-glucoside, Isosalipurposide,

(Blossoms)

2,3,4,4',5,6'-Hexahydroxychalcone-

2'-glucoside

"Hop extract"

293
48
HO OH OH
OMe
(Xanthohumol)

Larrea nitida

2',4'-Dihydroxy-3'-methoxychalcone

49

(Aerial parts)

(Larrein)

2',4'-Dihydroxychalcone

Lasthenia

Butein and Okanin

50

(Compositae)

<u>Lindera</u> umbellata

2',6'-Dihydroxy-4'-methoxychalcone

51-52

Thumb (Leaves)

Lonchocarpus serie

(Belgian Congo)

Seeds and roots

COCH=CH-Ph

Lyonia formosa

(Leaves)

MeO OH CO-CH(OH)-CH2-OH

(Lyonogenin)

and Lyonogenin-2'-glucopyranoside

(Lyonotin)

Butein and	55
Isoliquiritigenin	
2'-Hydroxy-3,4,4',6'-tetramethoxy-	56
chalcone,	
2',3-Dihydroxy-4,4',6'-trimethoxy-	
chalcone,	
2-Hydroxy-3,4,4',5',6'-pentamethoxy-	
chalcone	
2'-Hydroxy-3',C-prenyl-4',6'-	57
O OMe O	
Ö (Ovalitenin A)	
MeO OMe OMe Ovalitenin B)	
2',4'-Dihydroxy-6'-methoxy-3',5'-	58
dimethylchalcone	
2'-Hydroxy-4',6'-dimethoxy-3'-	58
methyl-dihydrochalcone	
	2'-Hydroxy-3,4,4',6'-tetramethoxy-chalcone, 2',3-Dihydroxy-4,4',6'-trimethoxy-chalcone, 2-Hydroxy-3,4,4',5',6'-pentamethoxy-chalcone 2'-Hydroxy-3',C-prenyl-4',6'-  O OMe  O (Ovalitenin B)  2',4'-Dihydroxy-6'-methoxy-3',5'-dimethylchalcone  2'-Hydroxy-4',6'-dimethoxy-3'-

Myrica gale	2',6'-Dihydroxy-4'-methoxy-3',5'-	59
(Fruits)	dimethyl-dihydrochalcone.	
	Me Me C-(CH ₂ ) ₂ -Ph	
Oenothera hookeri	Isosalipurposide	60
Onagraceae	Onagraceae: 13 species contain the	61
(Petals)	chalcone, while 27 species are	
	lacking in it	
Onychium auratum	2',6'-Dihydroxy-4',5'-dimethoxy-	62
(Fern)	chalcone,	
	2',6'-Dihydroxy-4'-methoxychalcone	63
Petunia hybrida	4,2',4',6'-Tetrahydroxychalcone	64
(Pollen)		
Piper methysticum	2',4'-Dihydroxy-4,6-dimethoxychalcone	65
Forst,		
(Roots)		
Pityrogramma	2',6'-Dihydroxy-4,4'-dimethoxy-	66
austroamericana	chalcone,	
(Gold-fern)	2',6'-Dihydroxy-4,4'-dimethoxy-	
(Yellow powdery	dihydrochalcone	
coating on the	요한 경기를 보고 있는 것이 되었다. 그는 사람들이 보고 있는 것이 되었다. 그런 것이다. 이 등 사람들은 사람들이 되었다면 있다. 그는 사람들이 하는 것이 되었다. 그런 사람들이 되었다.	
underside of fronds)	하다. 마르크 라이 그 보다는 마르크 마르크 등 마이트를 보고 있다. 기존 사람들은 사람들은 사람들은 사람들이 가장하는 이 경우를 보고 있다.	

Pityrogramma	2',6'-Dihydroxy-4'-methoxy-	67
calomelanos	dihydrochalcone,	
and		
P. tarterea (Exudate)	2',6'-Dihydroxy-4,4'-dimethoxy-	
(Jamaican ferns)	dihydrochalcone	
Pityrogramma	2',6'-Dihydroxy-4'-methoxychalcone	66
chrysophylla	2',6'-Dihydroxy-4,4'-dimethoxy-	68
heyderi (Fronds)	chalcone	
Pityrogramma	2',6'-Dihydroxy-4,4'-dimethoxy-	66
lehmanii	dihydrochalcone	
(Silver fern)		
White coating on the		
underside of fronds		
Pityrogramma	2',6'-Dihydroxy-3'-methyl-4'-	69
triangularis	methoxychalcone	
(Ferns) Exudate		
Podocarous nubigena	4,2',4,4',6'-Pentahydroxy-dihydro-	70
	chalcone (Nubigenol)	
Polygonum senegalese	2',4'-Dihydroxy-3',6'-dimethoxy-	71
(Seeds and leaves)	chalc one	
"Populus bud oils"	2',4',6'-Trihydroxychalcone,	72
(Several species or	2',6'-Dihydroxy-4'-methoxychalcone	

73

## Prunus cerasus L.

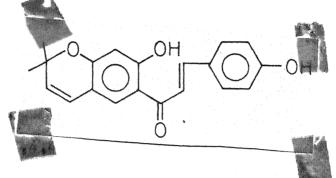
(Heartwood)

chalcone (Cerasidin)

2',4'-Dihydroxy-2,4,6'-trimethoxy-

chalcone (Cerasin)

# Psorelea corylifolia (Seeds)



Isobavachalcone,

74

4'-0-Methylchalcone,

5'-Formyl-2',4-dihydroxy-4'-

75

methoxychalcone

#### Rhododendron

canescens,

2',4,6'-Trihydroxy-4'-methoxy-

dihydrochalcone and Asebotin

76

77

78

R. nudiflorum and

R. roseum

# Salix acutifolia

(Bark)

2',4,4',6'-Tetrahydroxychalcone-6'-

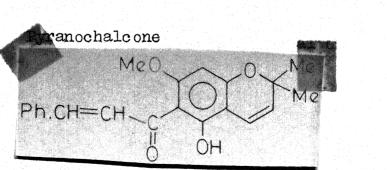
(6-0-p-Coumaroyl)-D-glucopyranoside,

Chalconaringenin-6'-D-glucoside

# Tephrosia obovata

Merr.

(Fish Poison Plant)



86

√,2',3,4,4'-Pentahydroxychalcone Trechylobium 79,80 verrucosum (Gaertn.) oliv. (Heartwood) Tulipa CV. "Apeldoorn" 2',3,4,4',6'-Pentahydroxychalcone 81 (During development 2'.4.4'.6'-Tetrahydroxy-3-methoxyof Anthers) chalcone, 2,4,4',6-Tetrahydroxychalcone Uvaria acuminata 82 (Roots) H0 (Uvareti Uvaria chamae Benzyldihydrochalconce: 83 Chamuvarin and chamuvaritin 2',4,4'-Trihydroxy-dihydrochalcone 84 Viburnum davidii Viburnum davidii Davidioside, 85 (Leaves) Davidigenin and 4'-methoxy derivative

Viseum album L.

2'-Hydroxy-4',6'-dimethoxychalcone

#### References

- 1. Drewes, S.E. and Roux, D.G., Biochem. J., 98, 493 (1966).
- 2. Imperato, F., Phytochem., <u>17</u>, 822 (1978)
- 3. Gennaro, A., Merlini, L. and Nasini, G., Phytochem., <u>11</u>, 1515 (1972).
- 4. Woolenweber, E., Jay, M. and Favre-Bonvin, J., Phytochem., 13, 2618 (1974).
- 5. Krishena, B.M. and Chaganty, R.B., Phytochem., 12, 238 (1973).
- 6. Kozawa, M., Morita, N., Baba, K. and Hata, K., Yakugaku Zasshi, 98, 210 (1978); Chem. Abstr., 88, 191090^d (1978).
- 7. Combes, G., Vassort, P. and Winternitz, F., Tetrahedron, <u>26</u>, 5981 (1970).
- 8. Gilbert, R.I., Phytochem., <u>12</u>, 809 (1973).
- 9. Volsteedt, F. du R., Rall, G.J.H. and Roux, D.G., Tetrahedron Letters, 1001 (1973).
- 10. Serbin, A.G., Borisov, M.I. and Chernobai, V.T., Khim. Prir. Soedin., <u>8</u>, 440 (1972); Chem. Abstr., <u>78</u>, 1987² (1973).
- 11. Barua, R.N., Sharma, R.P., Thyagarajan, G. and Hertz, W., Phytochem., 17, 1807 (1978).
- 12. Sokoloff, B.T., U.S. Patent 2,734,896 (1956); Chem. Abstr., 50, 7408^a (1956).
- 13. Gončalves de Lima, O., Marini-Bettolo, G.B., Francisco de Mello, J., Delle Monache, F., Coelho, J.S. de B., Lyra, F.D. de A. and Fernandes de Albuquerque, M.M., Atti. Accad. Naz. Lincei, Cl. Sci. Fis., Mat. Natur., Rend., 53, 433 (1973); Chem. Abstr., 80, 70483k (1974); 82, 1915g (1975).

- 14. Francisco de Mello, J., Delle Monache, F., Goncalves de Lima, O., Marini-Bettolo, G.B., Delle Monache, G., Lyra, F.D. de A., Fernandes de Albuquerque, M.M. and Leoncio d'Albuquerque, I., Rev. Inst. Antibiot. Univ. Fed. Pernambuco, Recife, 13, 37 (1973); Chem. Abstr., 82, 167508^b (1975).
- 15. Delle Monache, G., Francisco de Mello, J., Delle Monache, F., Marini-Bettolo, G.B., Concalves de Lima, O. and Coelho, J.S. de B., Gazz. Chim. Ital., 104, 861 (1974).
- 16. Goncalves de Lima, O., Francisco de Mello, J., Coelho, J.S. de B., Lyra, F.D. de A., Fernandes de Albuquerque, M.M., Marini-Bettolo, G.B., Delle Mouache, G., Delle Monache, F., Farmaco, Ed. Sci., 30, 326 (1975); Chem. Abstr., 83, 91495^t (1975).
- 17. Shimokoriyama, M., J. Am. Chem. Soc., 79, 214 (1957).
- 18. Pakudina, Z.P., Rakhimov, A.A. and Sadykov, A.S., Khim. Prir. Soedin (2), 126 (1969); Chem. Abstr., 71, 88425^S (1969).
- 19. Govindachari, T.R. and Parthasarthy, P.C., Tetrahedron Letters, 3419 (1972).
- 20. Govindachari, T.R., Parthasarthy, P.C., Desai, H.K. and Shanbhag, M.N., Tetrahedron, 29, 3091 (1973).
- 21. Cardillo, G., Merlini, L., Nasini, G. and Salvadori, P., J. Chem. Soc. C, 3967 (1971).
- 22. Giannasi, D.G., Mem. N.Y. Bot. Gard., 26, 125 (1975).
- 23. Laur, J. and Wrang, P., Phytochem., 14, 1621 (1975).
- 24. Zapesochnaya, G.G., Ban'kovskii, A.I. and Molodozhnikov, M.M., Khim. Prir. Soedin., <u>5</u>, 179 (1969); Chem. Abstr., <u>71</u>, 98962^d (1969).

- 25. Do-Nascimanto, M.C. and Mors, W.B., Phytochem., <u>11</u>, 3023 (1972).
- 26. Agarwal, S.C., Bhaskar, A. and Seshadri, T.R., Indian J. Chem., <u>11</u>, 9 (1973).
- 27. Bose, P.K., Chakrabarti, P., Chakrabarti, S., Dutta, S.P. and Barua, A.K., Phytochem., 12, 667 (1973).
- 28. Adityachaudhury, N., Kirtaniya, C.L. and Mukherjee, B., J. Indian Chem. Soc., 46, 964 (1969).
- 29. Cardillo, B., Gennaro, A., Merlini, L., Nasini, G. and Servi, S., Tetrahedron Letters, 4367 (1970).
- 30. Adityachaudhury, N., Kirtaniya, C.L. and Mukherjee, B., J. Indian Chem. Soc., 47, 508 (1970).
- 31. Adityachaudhury, N., Kirtaniya, C.L. and Mukherjee, B., Tetrahedron, 27, 211 (1971).
- 32. Adityachaudhury, N. and Kirtaniya, C.L., J. Indian Chem. Soc., 47, 1023 (1970).
- 33. Cardillo, B., Gennaro, A., Merlini, L., Nasini, G. and Servi, S., Phytochem., <u>12</u>, 2027 (1973).
- 34. Rao, J.M., Subrahmanyam, K. and Rao, K.V.J., Current Sci. (India), 44, 158 (1975).
- 35. Bhatt, S., Indian J. Chem., 13, 1105 (1975).
- 36. Rao, J.M., Babu, S.S., Subrahmanyam, K. and Rao, K.V.G., Current Sci., <u>47</u>, 584 (1978).
- 37. Furuya, T., Matsumoto, K. and Hikichi, M., Tetrahedron Letters, 2567 (1971).

- 38. Litvinenko, V.I., Maksyutina, N.P. and Kolesnikov, I.G., Zh. Obshch. Khim., 33, 296 (1963).
- 39. Horton-Dorge, (Mrs.) M., J. Pharm. Belg., <u>29</u>, 560 (1974); Chem. Abstr., 83, 111099^x (1975).
- 40. Pointet-Guillot, M., Brit. Patent, 901,086 (1962); Chem.

  Λbstr., <u>57</u>, 11318^a (1962).
- 41. Saitoh, T. and Shibata, S., Tetrahedron Letters, 4461 (1975).
- 42. Aritomi, M. and Kawasaki, T., Chem. Pharm. Bull., <u>22</u>, 1800 (1974); Chem. Abstr., <u>81</u>, 166401^d (1974).
- 43. Maruyama, M., Hayasaka, K., Sasaki, S., Hosokawa, S. and Uchiyama, H., Phytochem., 13, 286 (1974).
- 44. Gottlieb, O.R. and Regode Sousa, J., Phytochem., 11, 2841 (1972).
- 45. Kaufmann, H.P., El Baya, Abd El W., Fette, Seifen, Anstrichm., 71, 25 (1969).
- 46. Rimpler, H., Langhammer, L. and Frenzel, H.J., Planta Med., 11, 325 (1963).
- 47. Rimpler, H. and Haensel, R., Arch. Pharm., <u>298</u>, 838 (1965); Chem. Abstr., <u>64</u>, 13015^h (1966).
- 48. Verzele, M., Stockx, J., Fontijn, F. and Anteunis, M., Bull. Soc. Chim. Belges, <u>66</u>, 452 (1957); Chem. Abstr., <u>52</u>, 7243^d (1958).
- 49. Federiva, R., Kavka, J. and D'Arcangelo, Λ.Τ., An. Asoc. Quim. Argent., <u>63</u>, 85 (1975); Chem. Abstr., <u>83</u>, 203739^j (1975).

- 50. Bohm, B.A., Saleh, N.A.M. and Ornduff, R., Amer. J. Bot., 61, 551 (1974).
- 51. Hayashi, N., Takeshita, K., Nishio, N. and Hayashi, S., Chem. and Ind. (London), 49, 1779 (1969).
- 52. Nanao, H., Kenji, T., Noamichi, N. and Shuichi, H., Flavour Ind., <u>1</u> (6), 405 (1970); Chem. Abstr., <u>73</u>, 59214^h (1970).
- 53. Baudrenghien, J., Jadot, J. and Huls, R., Bull. Classe Sci., Acad. Roy. Belg., 39, 105 (1953); Chem. Abstr., 48, 10744^d (1954).
- 54. Shukla, Y.N., Tandon, J.S. and Dhar, M.M., Indian J. Chem., 11, 720 (1973).
- 55. Kurosawa, K., Ollis, W.D., Sutherland, I.O., Gottlieb, O.R. and De Oliveria, A.B., Phytochem., 17, 1389 (1978).
- 56. Fraser, A.W. and Lewis, J.R., Phytochem., 13, 1561 (1974).
- 57. Gupta, R.K. and Krishnamurti, M., Phytochem., <u>16</u>, 293, 1104 (1977).
- 58. Malterud, K.E., Anthonsen, T. and Lorentzen, G.B., Phytochem., 16, 1805 (1977).
- 59. Wyar, T., Malterud, K.E. and Anthousen, T., Phytochem., <u>17</u>, 2011 (1978).
- 60. Dement, W.A. and Raven, P.H., Phytochem., 12, 807 (1973).
- 61. Dement, W.A. and Raven, P.H., Nature, 252 (5485), 705 (1974).
- 62. Ramakrishnan, G., Banerji, A. and Chadha, M.S., Phytochem., 13, 2317 (1974).
- 63. Banerji, A., Ramakrishnan, G. and Chadha, M.S., India, A.E.C., Bhabha At. Res. Cent. (Rep.), BARC-764, 14 (1974); Chem. Abstr., 82, 108863^r (1975).

- 64. De Vlaming, P. and Kho, K.F.F., Phytochem., 15, 348 (1976).
- 65. Dutta, C.P., Ray, L.P.K., Chatterjee, (Mrs.) A. and Roy, D.N., Indian J. Chem., 11, 509 (1973).
- 66. Wollenweber, E., Pflanzenphysiol., <u>78</u>, 344 (1976); Chem. Abstr., <u>85</u>, 17060^x (1976).
- 67. Star, A.E. and Mabry, T.J., Phytochem., 10, 2817 (1971).
- 68. Nilsson, M., Acta Chem. Scand., 15, 211 (1961).
- 69. Star, A.E., Mabry, T.J. and Smith, D.M., Phytochem., <u>17</u>, 586 (1978).
- 70. Bhakuni, D.S., Bittner, M., Silva, M. and Sammes, P.G., Phytochem., 12, 2777 (1973).
- 71. Maradufu, A. and Ouma, J.H., Phytochem., 17, 823 (1978).
- 72. Wollenweber, E. and Weber, W., Pflanzenphysiol., <u>69</u>, 125 (1973); Chem. Abstr., 78, 133406^u (1973).
- 73. Nagarajan, G.R. and Parmar, V.S., Phytochem., <u>16</u>, 1317 (1977).
- 74. Bajwa, B.S., Khanna, P.L. and Seshadri, T.R., Current Sci., 41, 814 (1972).
- 75. Gupta, S.R., Seshadri, T.R. and Sood, G.R., Indian J. Chem., 13, 632 (1975).
- 76. Mabry, T.J., Sakakibara, M. and King, B., Phytochem., <u>14</u>, 1448 (1975).
- 77. Vinokurov, I.I. and Skrigan, A.I., Vestsi Akad. Nauk.

  Belarus. SSR, Ser. Khim. Nauk (5), 112 (1969); Chem. Abstr.,

  72, 55822^m (1970).
- 78. Chen, Y-L., Asian J. Pharm., <u>3</u>, 18 (1978); Chem. Abstr., <u>90</u>, 203903^c (1979).

- Vander Merwe, J.P., Ferreira, D., Bradt, E.V. and Roux, D.G., Chem. Commun., (9), 521 (1972).
- Soc., Perkin Trans., 12, 1492 (1974).
- Quast, L. and Wiermann, R., Experientia, 29, 1165 (1973).
- Ole, J.R., Torrance, S.J., Wiedhopf, R.M., Arora, S.K. and Bates, R.B., J. Org. Chem., <u>41</u>, 1852 (1976).
- 33. Okorie, D.A., Phytochem., 16, 1591 (1977).
- 84. Bohm, B.A. and Glennie, C.W., Phytochem., 8, 905 (1969).
- 85. Jensen, S.R., Nielsen, B.T. and Nern, V., Phytochem., <u>16</u>, 2036 (1977).
- 86. Becker, H., Exner, J. and Schilling, C., Z. Naturforsch., 33C, 771 (1978).

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	Analgesic and Sedative Action	

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<u>Introduction</u> :	

The presence of enone function in chalcone molecule confers upon it the antibiotic activity  $^{1-35}$  (bacteriostatic/bactericidal). This property is enhanced when substitution is made at the <-(nitro and bromo) and  $\beta$ -(bromo and hydroxylic) positions.  27  Some substituted chalcones and their derivatives, including some of their heterocyclic analogues, have been reported to possess some interesting biological properties, which are detrimental to the growth of microbes,  $^{23-26}$  tubercle bacilli,  $^{30-35}$  malarial parasites,  37  acrus,  38  Schistosoma  39  and intestinal worms.  25,40,41  Some of the compounds are claimed to be toxic to animals  $^{30.36}$  and insects  42,43  and are also reported to exhibit inhibitory action

on several enzymes, 53-61 fungi¹,3,17,22,48-51 and herbaceous plants. 45,47 The compounds of the chalcone series also show profound influence on the cardio-vascular cerebro-vascular and neuromuscular systems, including the vital organs of the experimental animals. 63-125 63-67,77-117,119-125 The data on the biological activities of these compounds are summarized in Table I.

Table I

Biological Activities of Chalcones

## Bacteriostatic or Bacterioidal Activity

Compound	Remarks	Test organism	Ref.
Chalcone	Significant bacterio-	E. coli	1
	static action.	S. aureus B. mycoides	
		B. subtilis S. lutea	
Chalcone	The bacteriostatic effect	S. aureus	2
	could not be reversed by		
	cystein, in contrast to		
	the effect of this com-		
	pound on other antibiotics.		
Chalcone	The antibacterial action	S.aureus 209P	3
	is associated with $ \alpha$ , $ \beta$ -	E.coli T.mentagrophytes	
	unsaturated carbonyl	C.albicans W.anomala	
	group of the molecule.	T.utilis A.usami P.chrysogenum Q 176 S.sake	

Prenylated chalcone	4-Hydroxyderricin	Gram-positive 4 microorganisms	• .
CHECKEONIC	exhibits a marked inhibi-	mitor our gairthmb	
	tory activity (in vitro).		
Halohydroxy-	Chalcones having 4'-		5
chalcones	hydroxyl and halogenic	S. aureus	
	substituents (in 2- and 4-		
	positions) possess marked		
	antibacterial activity.		•
	Also the chalcones with		
	fluoro substituent have		
	better antibacterial		
	activity compared to		
	bromo- or chloro-chalcones.		
Nitrohydroxy-	3'-Nitro-4'-hydroxy-2-	S. albus 6	,7
chalcone	methoxy chalcone has the		
	highest antibacterial acti-		
	vity (vivo). Other active		
	chalcones are: 3'-nitro-		
	4'-hydroxy-2,3-dimethoxy-		
	chalcone and 3'-nitro-4'-		
	hydroxy-2,5-dimethoxy-		
	chalcone.		
	그들이 요리는 어떤 사람들이 마시되었다. 이미를 걸 하고 말면 하는데 되었다. 눈의	化复数电路 医二氏管 电压电流 医二氏管炎性	

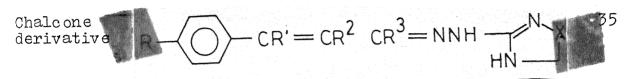
	· · · · · · · · · · · · · · · · · · ·			
	Nitrohydroxy- chalcones	The following chalcones	E. coli S. flexneri	8
		exhibit antibacterial	K. pneumoniae	
		activity:	S. aureus and S. albus	
		RCOCH=CHC6H40Me-m	strain resistant	
		R=2,5-, 4,3-, 4,2-, and	to streptomycin	
		2,4-(OH)NO ₂ C ₆ H ₃	and polymyxin	
	Nitrohydroxy-	3'-Nitro-4'-hydroxy-2-	S. albus (in vitro)	7
	chalcone	methoxy-chalcone has a		
		strong antibacterial action.		
	Aminochalcones	4- (and 4')-amino chalcones		9
		possess bacteriostatic	S. hemolyticus	
		activity.		
	Chlorohydroxy- chalcone	Antibacterial		10,11
	Bromohydroxy- chalcone	Anti bacterial	S. aureus	12
	Bromohydroxy- chalcone	4',5-Dibromo-2-hydroxy-		13
		chalcone has the highest		
		bacteriostatic activity		
		(1:640,000).		
	Bromohydroxy- chalcone	2,2'-Dihydroxy-3,5,5'-tri-	S. aureus	14
		bromo-chalcone possesses		
		bacteriostatic action.	. 19 1일 : 10 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
		Inhibitory concentration:		
		1:640,000.		

Iodohydroxy-	4'-Hydroxy-3',4,5'-tri-		-	15
chal <b>cone</b>	iodochalcone, 4'-Hydroxy-3',		•	
	5'-diiodo-4-propoxy (and 4-			
	butoxy)-chalcones and consi-			
	dered as possible antibac-			
	terial agents.			
Alkylthio-	The following chalcones	B. subtilis	16	
chalcones	possess antibacterial	NRRL E. coli 0-55		
	activity (in vitro):	S. aureus 209P		
	4'-Thioalkylchalcone and 4-	•		
	chloro-5'-methyl-2'-			
	thioalkyl chalcone.			
Sulphonic acid and carboxylic acid derivatives of chalcones	Bactericidal			17
Chalcone	Potential antibacterial			18
sulphanilamides	agents.			
Chalcone	2-Fluoro-3-nitro-4-			19,20
penicillanate	chalconyl-6-phenylacetamido-			
	penicillanate possesses			
	antibacterial action.			
Various chalcones	Bacteriostatic activity.	В.	abortus	21
Furan analogues of chalcone	Significant bacteriostatic action.	S. B. B.	coli aureus mycoidis subtilis lutea	1

Furan and 8- hydroxyquinolin analogue of chalcone		B. subtilis	22
Antimicrobial A	ctivity		
≪-substituted	Activity was increased by	Trichophyton	23
chalcones	<pre>c&lt;-bromination.</pre>		
Hydroxycarboxy	4'-Hydroxy-5'-carboxy-	B. subtilis	24
chalcones and their dihydro	chalcones, 4-chloro-4'-	S. hemolyticus and	
derivatives	hydroxy-5'-carboxychalcone	other bacteria in vitro	
	and 4-methoxy-4'-hydroxy-		
	5'-carboxydihydrochalcone		
	possess antimicrobial		
	activity (in vitro).		
Chalcone derivative	Methylene dithiodiacetic	Trichomonas	25
delivative	acid derivative (produced by	vaginalis	
	the reaction of chalcone		
	with monothiol acetic acid)		
	has antimicrobial action.		
∠ -Bromo- chalcones	Antimicrobial activity.		26
Antibiotic Acti	vity		
Chalcone	Antibiotic activity is asso-	교통 및 등 기계 1991년. 1922년 대 : 기계 1991년.	27
	ciated with the C=C bond of		
	the chalcone molecule.		
	Enhancement in antibiotic		
	activity results when		

	substitution is made at the		
c	$\chi$ -(nitro- and bromo) and $eta$ -		
	(bromo- and hydroxyl) posi-		
	tions respectively. Addition		
	of cystein or serum to		
	chalcones hampers activity		
	owing to their reduction		
	with SH group.		
Salicyclic	2'-Hydroxy-4'-carbethoxy		28
chalcones	chalcone has an antibiotic		
	activity.		
Furan analogue	Exhibits an antibiotic	E. coli	29
of chalcone	action.		
Tuberculostatic	and Anti-Tubercular Activity		
Furan analogue	Compared to thiomicid it	Rats	30
of chalcone	possesses lesser tubercu-		
	lostatic action and is		
	markedly toxic.		
Chalcone-2-	Potential anti-tubercular		31
hydroxy-4- acetamido- benzene sulphonyl hydrazone	compound		
Semicarbazone and thiosemi-	The highly effective anti-	Tubercle bacilli	32 33
carbazones of chalcone or its analogue	tubercular compounds are:		34
	a) Semicarbazones of thio- phene analogue of chalcone containing chloro- and nitro-substituents		

b) and those corresponding to the general formula:  $\begin{array}{c} p\text{-ROC}_6\text{H}_4\text{CH=CY-CØNNHSCNH}_2\\ \text{(R=alkyl, Y=MeO, COOH, or phenyl)} \end{array}$ 



R=Cl; OEt; Ph; CF₃, Br; SMe; SO₂Me; Me, OC(S)NMe₂; R'=H; 4-ClC₆H₄; 2-naphthyl; R²=H; Me; R³=substituted phenyl; 2-naphthyl; X=(CH₂)₁₋₃; CHMe

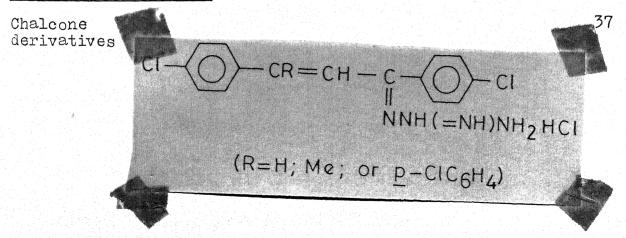
## Antiparasitic Activity

Thiophene analogues of chalcone

As possible antiparasitic

compounds.

## Antimalarial Activity



36

Acaricidal Acti	vity		•
Chalcone and some furan analogues	Exhibit acaricidal activity.	<b>-</b>	38
~			
Schistosomicida	1 Activity		
Chalcone derivatives	Thienyl pyrazolines derived	<b>-</b>	39
	from appropriate chalcones		
	are described as potential		
	schistosomicidal agents.		
Anthelminitic A	ctivity		
2',4'-Dihydro- xychalcone(s) and derivatives	a) Toxicity and local irri- tation are less than hexylresorcinol.	Ascaris	40
derivatives	b) Chalcone derivative, viz., 3,5-diphenylisoxa- zoline has shown anthel- mintic activity	Pin worms	41
	c) 2,2'-Dihydroxychalcone has also (in vitro) anthelmintic activity.	Amebae	41
Chalcone derivatives	Methylenedithiodiacetic	Shigella dysenteriae	25
UCI IVA DIVES	acid derivative of chalcone	dypenier 130	
	possesses antiprotozoal		
	activity.		
Insect Repellan	t and Insecticidal Activity		
Chalcone	Some chalcone derivatives		42
derivatives	are claimed to have insect		
	renellant properties		

Chalcone derivatives	N-substituted o-carbamoyl		43
del ivatory es	oxime of chalcone are		
	reported to exhibit a weak		
	insecticidal activity.		
Chalcone	Toxicity towards summer	Metatetra-	44
e - ⁴⁶	eggs and adult females of	nychus ulmi	
	fruit tree-red spider mite.	•	
Chalcone ⊄ , 3 -dichloride	Female flies mortality is	DDT resistant female flies	45
and DDT	92%.		
Toxicity to Ani	mals		
Furan analogue of chalcone	Markedly toxic.	Rats	30
Hydroxy- and methoxy-	When all the hydroxyl	Fresh water	46
chalcones	groups (in the polyhydroxy-		
	chalcone) are methylated,		
	the toxicity increases.		
Herbicidal Activ	vity		
Chalcone derivative	a) N-substituted o-carbamoyl oxime of chalcone exhibits weak herbicidal activity.		43
	b) Pyrazolium salts of chalcone are very effective as herbicides.	Lambsquarters and mustard	47
Pungistatic and	Fungicide Activity		
Substituted chalcones	2'-Hydroxychalcone	Mold and fungi	48
OTTONICO	sulphonic acid possesses a		
	weak antifungal activity.		

Substituted chalcones		<del>-</del> .	49
Substituted	Carboxylic and sulphonic	_	17
chalcones	acid derivatives of chalcone		
Substituted chalcones an (a) dihydro-chalcones	show fungicidal action.  COCH = CH	−ø mintho rium zae	50
(a)	CO CH ₂ CH ₂	Ø.lternaria solani and survularia unate (in witro)	
	c) 2',4'-dihydroxy-dihydrochalcone.		
Chalcone	Exhibits an antifungal	Fungi	1,3
	activity.		
Heterocyclic	Furan and 8-hydroxy-	Fungi	1,22
analogues of chalcone	quinoline		
X-chalcone and X-2-furan	Fungistatic activity is	F.graminearum P.digitatum	51
analogue of chalcone	associated with these	and B. allii	
	compounds.		
2-Hydroxy- 2'-carboxylic	Exhibits an antifungal	Cucumber mildew	52
chalcone	activity.		
Action on Enzyme	) <u>s</u>		
3,3',4,4'- Tetrahydroxy	Efficient inhibitor of	Rats	53,54
chalcone	liver xanthine oxidase		
	activity.		

s) 3,4-Dihydro- xy-3'-	Inhibits 5-hydroxy tryptopha	n -	55,56
carboxy chalcone;	decarboxylate		
b) 3,4,4'- Trihydroxy- 3'-carboxy chalcone			
a) Naringenin chalcone	Inhibitor of sodium-	Pig kidn <b>ey</b>	57
b) Hesperidin	potassium dependent ATP-		
chalcone	ase. The extent of inhibi-		
c) Coreopsin	tion is dependent upon the		
d) Phlorizin	number and position of the		•
e) Asebotin	hydroxyl groups. The para		
	hydroxylic function of		
	ring B (phlorizin) is		
	involved in the inhibitory		
	action.		
Some salicylic chalcones	Inhibits the aromatic L-	Guinea pig	58
CHATCOHES	amino-acid carboxylases,	kidney	
	(the standard for compa-		
	rison is <-methyl dopa).		
Chalcone and	a) These compounds inhibit	Papain	59
furan analogue of chalcone	the activity of papain,		
	and		
4	b) Inhibits cholinesterase		<b>55,</b> 56
	in horse serum		

c) Furan analogue of chalcone 60 has a marked ability to inhibit the activity of enzyme dihydroxy-phenylalanine decarboxylase.

various chalcones and dihydrochalcones

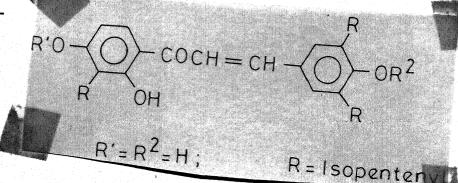
2',4,4'-Trihydroxy chalcone Wheat root 61 is a potent stimulator of indole acetic acid oxidase. It stimulates wheat-root growth, inhibits the absorption of sugars and of 2,4dichlorophenoxy acetic acid and inhibits oxidative phosphorylation and gives a distinct uncoupling effect. Inhibitory activity on L-62

Resorcylic chalcones

dopa decarboxylase.

Antipeptic Ulcer tivity

Isopentenylchalcone



63-67

These compounds have proved useful in the treatment of rat stomach ulcers.

	Chalcone derivatives	Useful in the treatment of	Rats	68-76
derivatives	gastrointestinal ulcers.			
	Prenyl-	Possess antipeptic ulcer	Rat	77
	oxychalcones	activity.		
	Prenyl	Exhibit antipeptic ulcer	Mice	78
	chalcones	activity.		• •
	Urmatanaire /Ant	i-hamenton dive Activity		
	nypo tensive/Ant.	i-hypertensive Activity		
	2;,4',6'- 1_ihydroxy-	Hypotensive property is asso-	<b>-</b> - 1	79
	chalcone	ciated with this chalcone.		
	a) -Amino- alkoxy	Compounds with antihyper-		80-84
	chalcones and acid	tensive properties.		
	addition salts			
	b) N,N-Disubs-			
	tituted-2- (w-amino-			
	alkoxy)-3', 4',5'-			
	trimethoxy- chalcone			
	c) Reduced			
	benzofuran chalcone			
	derivative			85
	Indole analogues of	Weakly hypotensive.		ره.
	chalcone			
	2-[3-(4- methyl-1-	Hypotensive action.		86,87
	piperazinyl) propoxy-4'-			
	methyl(and 4'-chloro)			
	chalcone hydro- chlorides and			
	related compounds			

4-Aminohalo- genochalcone (without a 2'-hydroxy substituent)	Hypotensive activity	•	49
Antitumor Activ	ity/Cytotoxic Activity		0.6
2,4,4'-	Antineoplastic action on	Mice	90
Trihydroxy- chalcone and	Ehrlich's ascitic sarcoma		
2',4,4',6'- tetrahydroxy- chalcone	in mice.		
Nitrochalcones, having nitro	These compounds show	Tested against normal and	89
group in 2- (and 2') and 4-(and 4'-) positions	cytotoxic activity.	Rous virus- transformed hamster fibro- blasts	
Isothiocyanato chalcones	4-Nitro-3'-isothiocyanato-	HeLa cells	90
cuarcones	chalcone is the most active		
	compound in respect of		
	cytoxicity and cancero-		
	static effect.		
Uvaretin (a dihydro-	HO	10	
chalcone from Uvaria			
acuminata)	2-HOC ₆ H ₄ CH ₂	(CH ₂ ) ₂ Ø	
	Uvaretin showed a anti-	-	91
	tumor activity in a lympho-		
	cytic leukemia test.	기계적 경우로 기름이 있다. 첫 18년 전 기본 기계 1년 1일	

		166
Plavonol derived from 2'-hydroxy-2, 4',5',6,6'- pentamethoxy chalcone	Potential antitumor compound	92
Choleretic/Hypo	ocholeretic Activity	
a) 4,4'-	These compounds exhibit a Rats	93
Dihydroxy- 2'-methoxy chalcone	greater activity thon the	
b) 2',4,4'- Trimethoxy- chalcone (vesidryl)	currently used choleretics.	61
a) 3'-Nitro-	Possesse choleretic Rats	6
4'-hydroxy- 2-methoxy chalcone	effect in vivo. Compound	
Guarcone	(a) has the highest	
	choleretic effect.	
b) 3'-Nitro- 4'-hydroxy- 2,3-dime- thoxy chalcone		
c) 3'-Nitro- 4'-hydroxy- 2,5-dime- thoxy chalcone		
2 ,4',6'- Trihydroxy	Hypocholeretic action.	79
	$CH = CH - C - O$ $R - R^{2}$ $R^{1}$ $R - R^{1} = H \cdot R^{2} = OMe$	

R ₃ =2-Morphi- noethyl sulphate			94
b) R=R ₁ =R ₂ =H; R ₂ =CH ₂ COOH			
Pyridine analogue of chalcone	Choleretic property.		95
Spasmolytic Act	ivity		
Chalcone; 2- (and 2')- Hydroxy chalcones; 2,4-dihydroxy- chalcone; 2,2'- dihydroxy- chalcone; 2,4,4'-trihy- droxy chalcone and 2,2',4- trihydroxy- chalcone	Exhibit spasmolytic action.	Isolated bowels and stomach of rats	96
Salts of N- substituted 4'-aminoalkoxy -2',4-dihydroxy chalcones	These compounds possess relatively high muscular spasmolytic and low neuro- spasmolytic properties.	Mouse	97
Reduced benzofuran chalcone derivatives	Compound with R=4-OH, and NR R ² =piperidine has the highest spasmolytic activity.		83

Bis(Phenyl-Potential spasmolytic 98 alkyl) aminesthe catalytic compounds. reduction products of chalcone oxime Licurzid 99 (chalcone) Antispasmodi Active i) R'= R2 = H; R3 = Me; ii)  $R' = H; R^2 = CH_3; R^3 = H$  $R' = CH_3; R^2 = R^3 = H$ 100,101  $R' = CR^2 - CO$ Me  $R^3 = H$  $X = CH_2$  $= CR^2 - CO$ Active 102 R1 = Me  $R^2 = R^3 = H$ 

CH₂

Anti-inflammato	ory Activity	
Substituted chalcones	- · · · · · · · · · · · · · · · · · · ·	49
5-Cinnamoyl salicylic acid		24
Analgesic and S	Sedative Action	
Substituted chalcones		49
5-(4-chloro- cinnamoyl)-	Analgesic effect is similar -	24
salicylic acid	to that of aspirin.	
aciu		
Antithrombie Ac	tivity	
Substituted chalcones		49
Flavone derived from	Potential antithrombic -	103
the following chalcone:	active compound.	
	OH	
	$\bigcirc$ COCH = CH $\bigcirc$ OH	
	OCH ₂ COOEt	

## Capillary Fragility

Various Restore capillary Guinea pigs 104 chalcones resistance.

Decreases capillary

105

106

fragility and also effects

venous circulation.

Chalcone and hesperidin methyl chalcone

These compounds effect the Mice fragility of capillaries present in the inner surface of the abdominal skin.

## Vasodilatory Activity

- a) Aminoal koxy chalcones and acid addition salts
- Coronary vasodilatory
  properties are associated
  with these compounds.

82**-**84,

b) Reduced benzofuran chalcone derivativés

Mecinarone (a benzofuranic	Vasodilatory activity (on	Experimental animals	108
chalcone)	the peripheral and cere-		
	bral circulation).		
Pyridine analogues of	Coronary vasodilative	<b>-</b>	95
chalcone	properties.		
Estrogenic Activ	<u>/i ty</u>		
2'-Hydroxy(and	These compounds produced	Mice	109
2'-chloro)-3,4 -methylene	uterotropic effect,		
dioxy-4'-fluoro-chalcones;	decreased the weight and		
and 2'-chloro- 4,4'-difluoro- chalcone	size of the testes and	, also	
CHATCOHE	seminal vesicles and		
	inhibited implantation in		
	the mouse.		
4,2',4'-Tri- methodychalcone epoxide and 4-methoxy-2', 4'-dibenzoyloxy chalcone	Estrogenic activity(?)	Rats	110
epoxide			
Anesthetic Activ	vity		
Pyrazole derived from	It has some local anes-		111
4-dimethyl amino chalcone	thetic activity.		
Anticoagulating	<u>Effect</u>		
2',4',6'- Trihydroxy chalcone	Anticoagulating properties.		79

Anticonvulsant/	Narcotic Potentiation Activity	
3,4-Methylene dioxychalcone	It has proved effective as -	112
	anticonvulsant; and also	
	shows narcotic potentiation	
	activity.	
Therapeutic Act	ivity	
Cyanomethyl- chalcones	These compounds are claimed -	113
	as valuable medicinal agents	
	for cardiovascular diseases	
	and endocrine dysfunctions.	· · · ·
Hesperidin	It exerts therapeutic action -	114
methyl carboxy chalcone	in the treatment of chronic	
	diseases of the eye and	
	kidney including rheumatoid	
	diseases like bursitis and	
	osteoarthritis.	
Hesperidin methyl chalcone	The compound, when incor- Cotton rats	115
	porated in diet (0.2%),	
	shows an inhibitory effect	
	on the incidence of	
	dental caries.	
Antiangiotensir	n/Antiarrhythmic/Diuretic Activity	
		85
Reduced benzofuran chalcone derivative (cf. spasmolytic activity)	These compounds possess -	ری
	antiangiotensin, antiarrhy-	
	thmic and diuretic	
	activity.	

119

### Miscellaneous Biological Activities

Chalcone, 2- hydroxy chalcone; 2',3-dihydroxy chalcone and hesperidin chalcone	These compounds are able	Isolated strip of intestine	116
	to protect adreline from		
	destruction (vitro).		
Dialkylamino alkoxy deriva- tive of chalcone	Potential adrenergic	<del>-</del>	117
	blocking agents.		
Aminoaza chalcones	Adrenal cortex inhibitors	Rats	118
Azachalcones:	Suprarenal gland inhibitors	Rat	122
	enone type.		
N	ese compounds		
-co-ci	H = CH - R tive than		

R=2pyriay1; R=ph; 4-NH-(Me)C6H4 or R=4-N(Me)2-C6H4

Substituted chalcones

The most potent compound in respect of pharmacological activity is 2(2-dimethyl-aminoethoxy) chalcone, but it does not compare with the available therapeutic agents in specificity, potency and duration of action.

Licurzid (chalcone)

- a) Reduces stomach motility.
- Rats and Mice 99

Dogs and rats

- b) Inhibits evacuation of water from stomach to deudenum.
- c) Inhibits development of exudative processes in the inflammation and prevents development of neurogenic and butadione stomach ulcers.

2-[2-dimethyl aminoethoxy)-3',4',5'-trimethoxy] chalcone hydrochloride

- a) This compound is an effective and long active depressor agent.
- b) There is an electrolytic alteration between
  blood vascular smooth
  muscles following
  treatment with the
  chalcone.

Sulphur containing Biological activity derivative of chalcone, viz.  $\emptyset$  COCH₂S-C₆H₄Cl, obtained by the interaction of the chalcone epoxide with thiol

121

120

#### Action on Spermatocytic Chromosomes

2',4'-Dihydroxy The rejoining of broken

Grasshopper

123

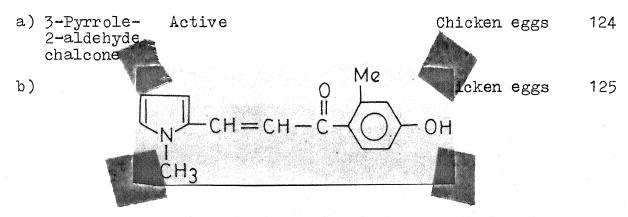
chalcone

ends of chromosomes and

chromatids is accelerated

by the addition of chalcone.

### Decrease in the Incidence of Blood Spots in Chicken Eggs



## Plant Growth Inhibiting Activity

3,2',4'-Inhibitory effect on the trihydroxy-4methoxygrowth of plant-triticale dihydrochalcone

Triticle

126

#### References

- 1. Geiger, W.B. and Conn, J.E., J. Am. Chem. Soc., <u>67</u>, 112 (1945).
- 2. Schraufstatter, E., Experientia, 4, 484 (1948).
- Ishida, S., Matsuda, A., Kawamura, Y. and Yamanaka, K.,
   Chemotherapy (Tokyo), 8, 146 (1960); Chem. Abstr., 54,
   22844^c (1960).
- 4. Goncalves de Lima, O., Francisco de Mello, J., Coelho, J.S. de B., Lyra, F.D. de A., Fernandes de Albuquerque, M.N., Marini-Bettolo, G.B., Delle Monache, G., Delle Monache, F., Farmaco, Ed. Sci., 30, 326 (1975); Chem. Abstr., 83, 91495^t (1975).
- 5. Gabor, M., Sallai, J., Széll, T. and Sipos, G., Acta Microbiol. Acad. Sci. Hung., 14, 45 (1967); Chem. Abstr., 67, 51338^g (1967).
- 6. Gabor, M., Sallai, J. and Széll, T., Kiserl. Orvostud., <u>20</u>, 540 (1968); Chem. Abstr., 70, 56156^t (1969).
- 7. Gabor, M., Sallai, J. and Szell, T., Acta Physiol. Budapest, 34, 227 (1968); Chem. Abstr., 71, 11692^u (1969).
- 8. Gabor, M., Sallai, J. and Szell, T., Arch. Pharm. (Weinheim), 303, 593 (1970); Chem. Abstr., 73, 106605 (1970).
- 9. Marrian, D.H., Russell, P.B. and Todd, A.R., J. Chem. Soc., 1419 (1947).
- 10. Ambekar, S., Vernekar, S.S., Acharya, S. and Rajagopal, S., J. Pharm. Pharmacol., 13, 698 (1961).

- 11. Gudi, N., Hiremath, S., Badiger, V. and Rajagopal, S.,
  Arch. Pharm., <u>295</u>, 16 (1962); Chem. Abstr., <u>57</u>, 7154^e (1962).
- 12. Jerchel, D. and Oberheiden, H., Angew. Chem., 67, 145 (1955).
- 13. Schraufstatter, E. and Deutsch, S., Z. Naturforsch., 3b. 430 (1948).
- 14. Schraufstätter, E. and Deutsch, S., Z. Naturforsch., 3b, 163 (1948).
- 15. Covello, M., Dini, A. and Piscopo, E., Rend. Accad. Sci. Fis. Mat., Naples, <u>37</u>, 56 (1970); Chem. Abstr., <u>76</u>, 33900^r (1972).
- 16. Hirose, K., Vkai, S. and Hattori, T., Yakugaku Zasshi, <u>91</u>,
   604 (1971); Chem. Abstr., <u>75</u>, 129467^k (1971).
- 17. Wurm, G., Arch. Phar. (Weinheim), 308, 142 (1975).
- 18. Calcinari, R., Farmaco, Ed. Sci., <u>27</u>, 397 (1972); Chem.
   Abstr., <u>77</u>, 48007^z (1972).
- 19. Aries, R., German Patent, 2,341,514 (1974); Chem. Abstr., 80, 146152^Z (1974).
- 20. Societe de Recherches, French Patent, 2,181,505; Chem. Abstr., <u>80</u>, 108509^p (1974).
- 21. Jeney, E. and Zsolnai, T., Acta Microbiol. Acad. Sci. Hung., (350) (2, 249 (1955); Chem. Abstr., 49, 1350) (1955).
- 22. Kushwaha, S.C., Dinkar, and Lal, J.B., Indian J. Chem., <u>5</u>, 82 (1967).
- 23. Gasha, M., Tsjuji, A., Sakurai, Y., Kurumi, M., Endo, T., Sato, S. and Yamaguchi, K., Yakugaku Zasshi, <u>92</u>, 719 (1972); Chem. Abstr., <u>77</u>, 97221^y (1972).

- 24. Lespagnol, A., Lespagnol, C., Lesieur, D., Cazin, J.C., Cazin, M., Beerens, H. and Romond, C., Chim. Ther., 7, 365 (1972); Chem. Abstr., 78, 52753° (1973).
- 25. Kishimoto, Y., Akabori, Y. and Horiguchi, T., Yakugaku Zasshi, <u>78</u>, 447 (1958); Chem. Abstr., <u>52</u>, 13863^b (1958).
- 26. Yamaguchi, K., Sakurai, Y. and Kurumi, M., Japanese Patent, 72,47,016 (1972); Chem. Abstr., 78, 97330^d (1973).
- 27. Schraufstatter, E. and Deutsch, S., Z. Naturforsch., 4b, 276 (1949).
- 28. Lespagnol, A., Lespagnol, C., Lesieur, D., Bonte, J.P.,
  Blain, Y. and Labiau, O., Chim. Ther., <u>6</u>, 192 (1971); Chem.
  Abstr., <u>75</u>, 98285^t (1971).
- 29. Kamoda, M. and Ito, N., J. Agr. Chem. Soc. Japan, <u>28</u>, 799 (1954); Chem. Abstr., <u>49</u>, 5573^b (1955).
- 30. Jeney, E., Zsolnai, T. and Lázár, J., Zentr. Bakteriol.

  Parasitenk, Abt. I, Orig. <u>163</u>, 291 (1955); Chem. Abstr., <u>49</u>, 15074^g (1955).
- 31. Lora- Tamayo, M., Municio, A.M. and Ruiz, J.L., Anales real Soc. Espan. Fiz. y quim. (Madrid), <u>56B</u>, 403 (1960); Chem. Abstr., <u>55</u>, 7410^a (1961).
- 32. Buu-Hoi, N.P., Xuong, N.D. and Sy, M., Bull. Soc. Chim. France, 1646 (1956); Chem. Abstr., <u>51</u>, 12063ⁱ (1957).
- 33. Bayer, F., British Patent 708,013 (1954); Chem. Abstr., <u>50</u>, 1086^b (1956).
- 34. Schmidt, H., Behnisch, R. and Schraufstätter, E., U.S. Patent 2,676,978 (1954); Chem. Abstr., <u>49</u>, 7596^h (1955)

- 35. Tomcufcik, A.S., Wilkinson, R.G. and Child, R.G., German Patent 2,502,490 (1975); Chem. Abstr., <u>83</u>, 179067^r (1975).
- 36. Laliberate, R., Manson, J., Warwick, H. and Medawar, G., Can. J. Chem., 46, 1952 (1968).
- 37. Henry, D.W., U.S. Patent, 3,726,920 (1973); Chem. Abstr., 79, 18450ⁿ (1973).
- 38. Velarde, E., Bol. Soc. Quím. Peru, <u>36</u>, 127 (1970); Chem. Abstr., <u>75</u>, 19808^q (1971).
- 39. El-Kerdawy, M.M., Samour, A.A. and El-Agamey, A.A.,
  Pharmazie, 30, 76 (1975); Chem. Abstr., 83, 9888^S (1975).
- 40. Takayanagi, Y., Ann. Rept. Tohoku Coll. Pharm. No. 1, 10 (1954); Chem. Abstr., 50, 4389^e (1956).
- 41. Laliberté, R., Campbell, D. and Bruderlein, F., Can. J. Pharm. Sci., 2, 37 (1967); Chem. Abstr., <u>67</u>, 98058^f (1967).
- 42. Nakanishi, M. and Tsuda, A., Japanese Patent, 74,46,056; Chem. Abstr., <u>83</u>, 38818² (1975).
- 43. Ruchkin, V.E., Shvetsova-Shilovskaya, K.D. and Melnikov, N.N., Probl. Poluch. Poluprod. Prom. Org. Sin., Akad. Nauk. SSSR, Otd. Obshch. Tekh. Khim., 66 (1967); Chem. Abstr., 68, 95417^g (1968).
- 44. Eaton, J.K. and Davies, R.G., Ann. Applied Biol., <u>37</u>, 471 (1950); Chem. Abstr., <u>45</u>,3111^h (1951).
- 45. Clark, S.F., U.S. Patent, 2,805,184; Chem. Abstr., <u>52</u>, P 2325ⁱ (1958).
- 46. Narasimhachari, N. and Seshadri, T.R., Proc. Indian Acad. Sci., 27A, 128 (1948).

- 47. Cross, B., U.S. Patent 3,925,408 (1975); Chem. Abstr., <u>84</u>, 135646 (1975).
- 48. Wurm, G. and Lachmann, C., Arch. Pharm., <u>307</u>, 695 (1974); Chem. Abstr., 81, 169399^V (1974).
- 49. Hsu, K.K., Chen, F.C., Tai-wan K'O Hsueh, <u>27</u>, 23 (1973); Chem. Abstr., <u>80</u>, 66597^h (1974).
- 50. Chowdhury, A., Mukherjee, N. and Adityachaudhury, N., Experientia, 30, 1022 (1974).
- 51. McGowan, J.C., Brian, P.W. and Hemming, H.G., Ann. Applied Biol., 35, 25 (1948); Chem. Abstr., 43, 9334 (1949).
- 52. Ko, K., Iseki, K., Adachi, Y., Konno, K., Yokoyoma, K. and Misato, T., Nippon Nayaku brakkaishi, <u>3</u>, 155 (1978); Chem. Abstr., <u>89</u>, 192310^h (1978).
- 53. Martin, G.J., Beiler, J.M. and Avakian, S., U.S. Patent 2,769,817 (1956); Chem. Abstr., <u>51</u>, 14815^d (1957).
- 54. Beiler, J.M., Graff, M. and Martin, G.J., Am. J. Digestive Diseases, 19, 333 (1952); Chem. Abstr., 47, 1198 (1953).
- 55. Kamoda, M., Chiba, T., Mori, K. and Ito, N., Botyu Kagaku, 18, 117 (1953); Chem. Abstr., 48, 778^c (1954).
- 56. Yuwiler, A., Geller, E. and Eiduson, S., Arch. Biochem.

  Biophys., 89, 143 (1960); Chem. Abstr., <u>54</u>, 21222^c (1960).
- 57. Hase, J., Kobashi, K. and Kobayashi, R., Chem. Pharm. Bull., 21, 1076 (1973); Chem. Abstr., <u>80</u>, 10261^b (1974).
- 58. Lesieur-Demarquilly, I., Mizon, J. and Osteux, R., Ann. Pharm. Franc., 31, 705 (1973); Chem. Abstr., 81, 59921b (1974).

- 59. Watanabe, M., Okada, K., Mori, K. and Ito, N., Botyu Kagaku, 17, 1 (1952); Chem. Abstr., 46, 7151 (1952).
- 60. Deutsch, D.H. and Garcia, E.N., U.S. Patent 2,754,299 (1956); Chem. Abstr., <u>51</u>, 4437^h (1957).
- 61. Stenlid, G., Physiol. Plant., <u>21</u>, 882 (1968); Chem. Abstr., 69, 84194^b (1968).
- 62. Lesieur-Demarquilly, I. and Lesieur, D., Bull. Soc. Pharm., 34, 9 (1978).
- 63. Komatsu, M., Kyogoku, K., Hatayama, K., Suzuki, K. and Yukomori, S., Japanese Patent 7405,950 (1974); Chem. Abstr., 80, 120551^d (1974)
- 64. Kyogoku, K., Hatayama, K., Yokomori, S. and Seki, T., Japanese Patent 74,126,654 (1974); Chem. Abstr., <u>83</u>, 78864^t (1975).
- 65. Kyogoku, K., Hatayama, K., Yokomori, S. and Seki, T., Japanese Patent 7524,258 (1975); Chem. Abstr., <u>83</u>, 178566^r (1975).
- 66. Kyogoku, K., Hatayama, K., Yokomori, S. and Seki, T., Japanese Patent 7524,257 (1975); Chem. Abstr., 83, 178566 (1975).
- 67. Kyogoku, K., Hatayama, K., Yokomori, S. and Seki, T., Japanese Patent 75,140,430 (1975); Chem. Abstr., <u>84</u>, 121467^e (1975).
- 68. Kyogoku, K., Hatayama, K., Yokomori, S., Swada, J. and Tanaka, I., Japan Kokai, 7797,950 (1977); Chem. Abstr., 88, 74200^d (1978).

- 69. Vanstone, A.E. and Maile, G.K., Ger. Offen 2,810,253 (1977); Chem. Abstr., 90, 22628^W (1979).
- 70. Kyogoku, K., Hatakeyama, M., Yokomori, S., Swada, J. and Tanaka, I., Japan Kokai Tokkyo Koho 78,116,355 (1978); Chem. Abstr., 90, 87056° (1979).
- 71. Kyogoku, K., Hatakeyama, M., Yokomori, S., Miyata, Y., Swada, J. and Tanaka, I., Japan Kokai Tokkyo Koho 7919,48 (1977); Chem. Abstr., 89, 90260^Z (1978).
- 72. Biorex Laboratories Ltd., Fr. Demande 2,383,157 (1978); Chem. Abstr., 91, 39136° (1979).
- 73. Kyogoku, K., Hatakeyama, M., Yokomori, S., Miyata, Y., Sawada, J. and Tanaka, I., Japan Kokai Tokkyo Koho 7919,947 (1979); Chem. Abstr., 91, 20114^x (1979).
- 74. Kyogoku, K., Hatayama, K., Yokomori, S., Sawada, J. and Tanaka, I., Fr. Demande 2,340,924 (1977); Chem. Abstr., 88, 104910⁶ (1978).
- 75. Kyogoku, K., Hatakeyama, M., Yokomori, S., Miyata, Y., Sawada, J. and Tanaka, I., Japan Kokai Tokkyo Koho 7919,949 (1979); Chem. Abstr., 90, 203699^r (1979).
- 76. Kyogoku, K., Hatakeyama, M., Yokomori, S., Miyata, Y., Sawada, J. and Tanaka, I., Japan Kokai Tokkyo Koho 7922,349 (1979); Chem. Abstr., 90, 203690^f (1979).
- 77. Kyogoku, K., Hatayama, K., Yokomori, S. and Seki, T., Belgium Patent, 816,463 (1974); Chem. Abstr., <u>83</u>, 43051^y (1975).

- 78. Kyogoku, K., Hatayama, K., Yokomori, S. and Seki, T.,

  Japanese Patent 75,140,429 (1975); Chem. Abstr., <u>85</u>, 5913^q

  (1976).
- 79. Lafon, L., Ger. Offen, 2,010,180 (1970); Chem. Abstr., <u>73</u>, 120342⁸ (1970).
- 80. Mizuta, Y., Igasa, H. and Uno, J. and Tsukamoto; M.,

  Japanese Patent 7421,125 (1974); Chem. Abstr., <u>82</u>, 86208^b

  (1975).
- 81. Igasa, H., Tsukamoto, M. and Uno, J., Japanese Patent 7337,027 (1973); Chem. Abstr., <u>80</u>, 120553 (1974).
- 82. Igasa, H., Mizuta, Y., Tsukamoto, M. and Uno, J., Japanese Patent 7,421,126 (1974); Chem. Abstr., 82, 97841^d (1975).
- 83. Raynaud, G., Pourrias, B., Thomas, J., Thomas, M., Roblin, B., Hecaen, V. and Perroud, F., Eur. J. Med. Chem. Chim. Ther., 9, 85 (1974); Chem. Abstr., 81, 99240^k (1974).
- 84. Raynaud, G., Pourrias, B., Thomas, J. and Thomas, M.,
  Chim. Ther., 8, 479 (1973); Chem. Abstr., 81, 45196^g (1974).
- 85. Venturella, P., Bellino, A. and Piozzi, F., Farmco, Ed. Sci., <u>26</u>,591 (1971); Chem. Abstr., <u>75</u>, 88432^z (1971).
- 86. Kinugasa, H., Tsukamoto, M., Mizuta, Y. and Uno, J.,

  Japanese Patent 7406,904 (1974); Chem. Abstr., <u>80</u>. 145797^b

  (1974).
- 87. Mizuta, Y., Kinugasa, H., Uno, J. and Tsukamoto, M.,

  Japanese Patent 7406,903 (1974); Chem. Abstr., <u>80</u>,

  146198^u (1974).

- 88. Kabiev, O.K. and Vermenichev, S.M., Izv. Akad. Nauk. Kaz. SSR. Ser. Biol., <u>9</u>, 72 (1971); Chem. Abstr., <u>75</u>, 47091^u (1971).
- 89. Dore, J.C. and Viel, C., J. Pharm. Belg., <u>29</u>, 341 (1974); Chem. Abstr., <u>83</u>, 90650^c (1975).
- 90. Horakova, K., Drobinca, L. and Nemec, P., Neoplasma, <u>18</u>, 355 (1971); Chem. Abstr., <u>75</u>, 107958^u (1971).
- 91. Cole, J.R., Torrance, S.J., Wiedhopf, R.M., Arora, S.K. and Bates, R.B., J. Org. Chem., 41, 1852 (1976).
- 92. Uong, T., Yan, C-F. and Chen, F.C., Hua Hsueh, (4), 133 (1973); Chem. Abstr., 81, 120380^t (1974).
- 93. Chabannes, B., Gradgeorge, M., Duperray, B., Pacheco, H., Chim. Ther., 8, 621 (1973); Chem. Abstr., 81, 20752^X (1974).
- 94. Flammang, M., Wermuth, C.G. and Delassue, H., Chim. Ther., 5, 431 (1970); Chem. Abstr., 74, 125043^a (1971).
- 95. Laboratoires Gerda Fr. M., 6427; Chem. Abstr., <u>75</u>, 40406^s (1971).
- 96. Formanek, K., Höller, H., Janisch, H. and Kowac, W., Pharm. Acta Helv., <u>33</u>, 437 (1958); Chem. Abstr., <u>53</u>, 15380^h (1959).
- 97. Woelm, F.M., German Patent 1,174,311 (1964); Chem. Abstr., 61, P11933^g (1964).
- 98. Dornow, A. and Frese, A., Arch. Pharm., <u>285</u>, 463 (1952); Chem. Abstr., <u>48</u>, 11374^a (1954).
- 99. Obolentseva, G.V. and Khadzhai, Y.I., Vop. Izuch. Ispol'z Solodki Nauka., 163 (1966); Chem. Abstr., <u>67</u>, 107314^r (1967).

- 100. Oshiro, S., Nagura, T., Sugihara, Y., Okamoto, K., Ishida, R. and Shintomi, K., Japanese Patent 7319,569 (1973); Chem. Abstr., 78,1478888 (1973).
- 101. Oshiro, S., Nagura, T., Sugihara, Y., Okamoto, K., Ishida, R. and Shintomi, K., Japanese Patent 7319,570 (1973); Chem. Abstr., 78, 147790^b (1973).
- 102. Oshiro, S., Nagura, T., Sugihara, Y., Okamoto, K., Ishida, R. and Shintomi, K., Japanese Patent 7319,594 (1973); Chem. Abstr., 78, 147963^k (1973).
- 103. Yan, C.F., Uong, T. and Chen, F-C, Hua Hsuch, (4), 135 (1973); Chem. Abstr., 81, 120382 (1974).
- 104. Huges, E.G. and Parkes, M.W., Jubilee Vol. Emil, Barell, 216 (1946); Chem. Abstr., 41, 2141^a (1947).
- 105. Fabre, P.S.A., French Patent, 2,183,612 (1974); Chem. Abstr., 80, 121294 (1974).
- 106. Lockett, M.F. and Jarman, D.A., Brit. J. Pharmacol., <u>13</u>, 11 (1958).
- 107. Uno, J., Kinugasa, H., Tsukamoto, M. and Mizuta, Y., Japanese Patent 7,249,581 (1972); Chem. Abstr., <u>78</u>, 147569^m (1973).
- 108. Fourrias, B., Sergant, M., Thomas, J., Gouret, C. and Raynaud, G., Arzneim.-Forsch., <u>25</u>, 782 (1975); Chem. Abstr., 83, 91023ⁿ (1975).
- 109. Jacob, D. and Kaul, D.K., Acta Endocrinol. (Copenhagen), 74, 371 (1973); Chem. Abstr., 80, 22992^d (1974).

- 110. Sharma, R.C., Gupta, S.K., Gupta, L. and Arora, R., Indian J. Exp. Biol., <u>10</u>, 455 (1972).
- 111. Hosni, G. and Saad, S.F., Acta Chim. Acad. Sci. Hung., 86, 263 (1975); Chem. Abstr., 84, 30959 (1976).
- 112. Unicler, S.A., French Patent, 2,253,503 (1975); Chem. Abstr., 84, 89825^c (1976).
- 113. Rorig, K.J., U.S. Patent, 2755,299 (1956); Chem. Abstr., 51, 2868^c (1957).
- 114. Hart, B.F., U.S. Patent, 2,962,162 (1960); Chem. Abstr., 54, 12161^g (1960).
- 115. Thompson, D.T., Vogel, J.J. and Phillips, P.H., J. Dental. Res., <u>44</u>, 596 (1965); Chem. Abstr., <u>63</u>, 7526^d (1965).
- 116. Wilson, R.H. and DeEds, F., J. Pharmacol. Exptl. Therap., 95, 399 (1949); Chem. Abstr., 43, 5542a (1949).
- 117. Packman, A.M. and Rublin, N., Am. J. Pharm., <u>134</u>, 45 (1962).
- 118. Nagy, A., Misikova, E. and Heger, J., Cerk. Farm., <u>26</u>, 140 (1977); Chem. Abstr., 88, 6671^h (1978).
- 119. Rossi, G.C. and Packman, E.W., J. Am. Pharm. Assoc., <u>47</u>, 640 (1958).
- 120. Sherman, G.P., Dissertation Abstr., 29B, 2145 (1968).
- 121. Ukai, S., Hirose, K., Hattori, T., Kayano, M. and Yamamoto, C., Yakugaku Zasshi, <u>92</u>, 278 (1972); Chem. Abstr., <u>77</u>, 34207^c (1972).
- 122. Durinda, J., Szucs, L., Struharova, L., Kolena, J. and Heger, J., Cesk. Farm., <u>21</u>, 276 (1972); Chem. Abstr., <u>78</u>, 29576^p (1973).

- 123. Saha, A.K. and Khudabaksh, A.R., Cytologia, <u>39</u>, 359 (1974); Chem. Abstr., <u>81</u>, 146348^b (1974).
- 124. Bigland, C.H., Bennett, E.B. and Abbott, U.K., Proc. Soc. Exptl. Biol. Med., <u>116</u>, 1122 (1964).
- 125. Bigland, C.H., Bennett, E.B. and Abbott, U.K., Poultry Sci., 44, 140 (1965).
- 126. Telenyl, Mrs. P., Talajtan, <u>26</u>, 391 (1977); Chem. Abstr., <u>88</u>, 164842^u (1978).

## CHAPTER - 18.1

## CHALCONE EPOXIDES

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#### Synthesis:

Epoxy derivatives of chalcones, and their heterocyclic analogues, viz., thienyl, selenthenyl and pyridyl, have been prepared by the following methods:

- i) By Darzens condensation of aldehydes with haloacyl compounds.
- ii) By the oxidation of chalcones and their heterocyclic analogues with alkaline hydrogen peroxide. This method has been exploited for the synthesis of the epoxides derived from vinyl-2 and o-methoxychalcones3.

#### Reactions:

A review on the reactions of substituted chalcone epoxides has been published.⁴

## With Toluene:

Friedel-Craft alkylation of epoxychalcones with toluene, in presence of anhydrous AlCl₃, is reported⁵ to yield indenes (I).

$$R = H, Me, Ph;$$

$$R' = H, 3,4-0CH, 0$$

$$R' = H, 3,4-0CH, 0$$

# With Thiophenols and Thioalcohols 7:

The following example illustrates the types of products (IV, V and VII) formed in the reaction of chalcone epoxide with thiophenol. An analogous reaction occurs with the thioalcohols, wix.,

$$\varphi SCH_{2}CO\varphi + \varphi CHO \xrightarrow{\text{Michael cond-}} \varphi CH CH(S\varphi)CO\varphi^{\overline{q}}_{2}$$
(IV) (V) (VII)

## With Amines^{5,8,9}:

Several amines,  $R^2H$ , react with chalcone epoxides to yield  $R-C_6H_4COCH(OH)CHR^2-C_6H_4R'$ . The amines used in the reaction are: pyridine, morpholine, N-methylaniline, diethylamine, benzylamine and p-tolylamine.

# With Hydroxylamines^{5,6}:

Isoxazoles (VIII) are produced by the interaction of chalcone epoxides and hydroxylamine:

$$R = \langle O \rangle$$
 $\langle R = Me, Ph \rangle$  (VIII)

## With Hydrazines:

Substituted chalcone epoxides are reported to react with hydrazine 5,6,9-11 or its substituted derivatives to yield 3,5-

$$R \longrightarrow \bigvee_{N=NR^2} \bigcirc \longrightarrow R'$$
(1X)

R=Me, H; R'=H, MeO; R²=H, Ø, C6H3(NO₂)₂

2-Phenyl-benzimidazole (10%) has been secured 12 by the reaction of o-phenylenediamine with trans chalcone epoxide.

## With Reducing Agents:

Trans-chalcone epoxide on reduction with lithium aluminium hydride 13 gives the mixture of erythro-1,3-diphenyl-1,2-propandio1

and (±) 1,3-diphenyl-1,2-propandiol. The same products are produced when trans-chalcone is catalytically hydrogenated over PtO₂. 13. 2'-benzyloxychalcone epoxide on treatment with KBH₄ or LiAlH₄-AlCl₃ (1:7) is reported 14 to yield trans-2,3-cis-3,5-flavandiol (X). However, the epoxide of 2'-methoxymethoxy chalcone under these conditions, gives a mixture of two isomeric diols (X) and (XI), the former predominating:

Chalcone and 1,4-dibenzoyl-2,3-diphenylbutane are produced when chalcone epoxide is reduced by chromous chloride. 15

#### Acids

#### With HCl:

The kinetics and mechanism of the cyclisation of 2'-hydroxy-chalcone epoxide to the 3-hydroxyflavanone in water has been investigated. The treatment of 2'-(4-methoxybenzyl)-4,4'-dimethoxychalcone epoxide with HCl in acetic acid is reported to give trans 3-hydroxy-7,4'-dimethoxyflavanone. On the other hand, trans 4'-methoxychalcone epoxide on treatment with HCl furnishes the corresponding chlorohydrins. The chlorohydrins have been found by N.M.R. Spectroscopy to correspond to three and erythro configurations respectively. Under the same conditions,

Epoxide

3-nitrochalcone, however, yields only one isomer, 18 viz., erythro. Several chlorohydrins (erythro and threo) have been synthesized. 19,2 The reaction of hydrazine with several chlorohydrins have been studied. 10

### With Dry HCl in Ether:

The treatment of 4'-methylchalcone, with dry HCl in ethereal solution yields 1-(p-tolyl)-2-hydroxy-3-chloro-3-phenylpropan-1-one. 21 The effect of various functional groups (R and R') on the oxirane ring pening by HCl or BF₃ has been studied. 22

R, R' = Me₂N, H; MeO,  $\emptyset$ CH₂O; Br, H; NO₂,  $\emptyset$ CH₂O

2-Nitrochalcone epoxide (XII) reacts with ethereal hydrogen chloride to yield 6-chlor-1,3-dihydroxy-2-phenylquinolin-4-(1H)-one  23  (XIII). The same reactants in the presence of quinol, gives the unchlorinated product  23  (XIII, R = H).

$$R = H$$

$$R = H$$

$$R = CI$$

$$(XIII)$$

The mechanism of this reaction can be rationalized as

follows 
$23$
,  14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   14   1 

resulting in the formation of nitrosophenyl ketone. The nitroso group can be reduced to hydroxylamine group before cyclisation can occur. Quinol serves this purpose, and the unchlorinated product (XIII, R = H) is thereby obtained. However, hydrogen chloride acting alone can cause reduction by insertion (at position 6) of chloride ion into the original nitrophenyl nucleus (XIII; R = Cl).

Substituted 2'-benzyloxychalcone epoxides react with HCl saturated ether to yield either chlorohydrins or flavon-3-ol (or both) depending upon the value of (the substitution constant 24) of the substituent in ring A. Treatment of the epoxide of 2'-benzyloxychalcone analogue-containing condensed rings and or heterocyclic ring system, with HCl-Et₂O yield the chlorohydrins. 24

## With Dilute Sulphuric Acid in Methanol²⁵:

Racemic 4',5,7-tri-0-methylaromadendrin and 3',4',5,7-tetra-0-methyl taxifolin have been prepared 26 in an analogous manner.

### With Ethanol-HCl:

2'-Benzyloxychalcone epoxide and 2'-benzyloxy-4-methoxy-chalcone epoxide exhibit a contrast in their behaviour towards ethanolic-HCl. Thus, in the presence of ethanol-HCl, the former epoxide undergoes cyclisation to give 3-hydroxyflavanone.  27  In this example the benzyl group is split off earlier than the cleavage of the oxirane ring and the 2'-phenolate ion formed attacks the  $\beta$ -carbon atom,  27,28  and thus effects cyclisation to 3-hydroxyflavanone. On the other hand 2'-benzyloxy-4-methoxy-chalcone epoxide, reacts with ethanol to give 2'-benzyloxy-4-

methoxy- $\chi$ -hydroxy- $\beta$ -ethoxy-dihydrochalcone (XIV-A). Treatment of (XIV-A) with HCl results in the formation of 1-(2-benzyloxy-phenyl)-2-hydroxy-3-chloro-3(p-methoxyphenyl)-propan-1-one  27  (XIV-B)

### With Boron Trifluoride Etherate:

5-substituted chalcone epoxides react with BF₃-Et₂0 (including HCl) to give different products viz., flavonol, 19 isoflavone 19 or chlorohydrin 19,20 depending upon the Hammett walks 19 of 5'-substituent

value¹⁹ of 5'-substituen

$$Et_2O-BF_3 / HCI / OHO$$

$$R^2 / HCI / ORO OHO OHO$$

$$R^2 / CO / ORO OHO OHO OHO
$$R^2 / R^2 / CO / ORO OHO OHO$$

$$R^2 / CO / ORO OHO OHO
$$R^2 / CO / ORO OHO OHO$$$$$$

gry yields

2'-Tosylchalcone epoxide on treatment with BF3-Et20, a mixture of 3-hydroxyflavanone and flavonol, 29 on the other hand, 6'-methoxy-2'-tosylchalcone epoxide yields the ketoaldehyde (XV):

The addition of methanol to chalcone epoxide is reported 30 to take place according to the equation:

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R = 4-0Me;  $3-NO_2$  and  $4-NO_2$ 

addition product.

### With Alkalis:

2'-Tosylchalcone epoxide (XVII; R = H) with caustic alkali in methanol is reported to give flavanol, while on the other hand 2'-tosyl-6'-methoxychalcone (XVII; R = OCH₃) at room temperature or in refluxing solvent, yields 4-methoxyaurone:

OTs

# With Stannous Chloride 31:

2-Methoxychalcone epoxide (XVIII) is reported to yield 1-(2-methoxybenzoyl)-2-phenyl-ethylene chlorohydrin (XIX) when the benzene solution of the former is reacted with stannous chloride. XIX is transformed by heating (140-150°) into an <a href="https://distriction.org/">-diketone or into a diol by hydrogenation over Pd-C catalyst. Under the same conditions, XVIII gives a ketoalcohol.</a>

Based on kinetic experiments the following mechanism has been reported 32 for the ring opening of chalcone epoxides:

### Miscellaneous Properties:

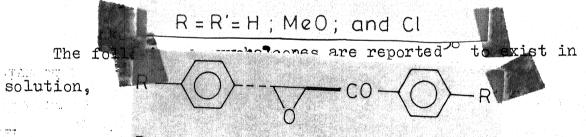
Quantum chemical methods  28,33  indicate that the para substituent (B consists at the electron density at the  $\beta$  -carbon atom.  $\frac{CO}{\alpha} \frac{\beta}{\beta} = R$  OCH2  $\phi$ 

On the bases of imprared spectroscopic and it has been demonstrated 34 that oxirane ring of chalcone epoxides exert an electron withdrawing influence on the carbonyl group and thereby decrease its basicity.

R = H, MeO and NO2

#### Conformation:

The conformation of chalcone epoxides has been derived both from spectroscopic studies 34,35 as well as from dipole moment measurements 37 Thus a conjugated cisoid conformation, in the solid state as well as in CCl₄ solution has been reported for 2'-benzyloxychalcone epoxide. 35 The gauche conformation 36 is adopted in solid phase by the epoxides of chalcone, 4,4'-dimethoxychalcone and 4,4'-dichlorochalcone, which, however, changes in solution (chloroform/carbon tetrachloride) to a gauchecis mixture. 36 Based on the dipole moment studies the following chalcone epoxides are reported 37 to exist probably as an equilibrium mixture.



R, R' = H, H; H, OMe; H, Br; Br, H; NO₂, H and H, NO₂

as equilibrium mixtures of polar gauche and onformers

The absolute configuration of chalcone epoxide, based on chemical correlation, has appeared in literature. 39

#### References

- Korotkov, S.A., Orlov, V.D. and Lavrushin, V.F., Visn. Kharkiv. Univ., Khim., <u>84</u>, 72 (1972); Chem. Abstr., <u>78</u>, 124358^c (1973).
- 2. Roshka, G.K., Ivanov, N.V. and Shur, A.M., Zh. Vses. Khim.
  0-va., 19, 703 (1974); Chem. Abstr., 82, 125192^p (1975).
- Pendse, H.K. and Limaye, S.D., Rasayanam, <u>2</u>, 80 (1955);
   Chem. Abstr., 50, 11333^c (1956).
- Litkei, G. and Bognar, R., Kem. Kozlem., <u>34</u>, 249 (1970);
   Chem. Abstr., 74, 87706^j (1971).
- Sammour, A., Selim, M. and Hamed, A.A., Egypt. J. Chem.,
   16, 101 (1973); Chem. Abstr., 80, 95816 (1974).
- 6. Hamed, A.A., Essawy, A. and Salem, M.A., Indian J. Chem., 16B, 693 (1978).
- 7. Malashko, P.M. and Tishchenko, I.G., Zh. Organ. Khim., <u>5</u>, <u>70</u> (1969); Chem. Abstr., <u>70</u>, 87398^c (1969).
- 8. Belyaev, V.F. and Abrazhevich, A.I., Zh. Organ. Khim., <u>5</u>, 352 (1969); Chem. Abstr., 70, 114767^f (1969).
- 9. Belyaev, V.F. and Prokopovich, V.P., Vestsi Akad. Nauk Belarus SSR Ser. Khim. Nauk (6), 109 (1969); Chem. Abstr., 72, 78775ⁿ (1970).
- 10. Litkei, G., Neubauer, A. and Bognar, R., Magyar Kem. Folyoirat, <u>78</u>, 359 (1972); Chem. Abstr., <u>77</u>, 101451^t (1972).
- 11. Neubauer, A., Litkei, G. and Bognar, R., Tetrahedron, 28, 3241 (1972).

- 12. Dhar, D.N., Munjal, R.C. and Bose, K., Ann. Chim. (Rome), 63, 757 (1973).
- 13. Chopin, J. and Piccardi, G., C. R. Acad. Sci., Paris Ser. C, 267, 895 (1968); Chem. Abstr., 70, 19703 (1969).
- 14. Piccardi, G. and Chopin, J., Bull. Soc. Chim. France, (1), 230 (1971).
- 15. Cole, W. and Julian, P.L., J. Org. Chem., 19, 131 (1954).
- 16. Main, L. and Old, K.B., Tetrahedron Letters, 2809 (1977).
- 17. Clark-Lewis, J.W. and Tucker, P.G., Aust. J. Chem., <u>29</u>, 1397 (1976).
- 18. Reichel, L. and Neubauer, A., Z. Chem., 8, 423 (1968).
- 19. Litkei, G. and Bognar, R., Acta Chim. (Budapest), <u>77</u>, 93 (1973); Chem. Abstr., <u>79</u>, 78534^c (1973).
- 20. Korotkov, S.A., Orlov, V.D., Pivnenko, N.S. and Lavrushin, V.F., Ukr. Khim. Zh., <u>39</u>, 1263 (1973); Chem. Abstr., <u>80</u>, 70477^m (1974).
- 21. Sammour, A-M. A. and Elkasaby, M., U.A.R. J. Chem. <u>13</u>, 151 (1970); Chem. Abstr., <u>74</u>, 141176^h (1971).
- 22. Dinya, Z., Litkei, G., Bognar, R., Matyas, G., Rochiltz, S. and Jekel, P., Acta Chem. (Budapest), 77, 323 (1973); Chem. Abstr., 79, 91383^x (1973).
- 23. Sword, I.P., J. Chem. Soc., C, 820 (1971).
- 24. Litkei, G., Bognar, R. and Dinya, Z., Acta Chim. (Budapest), 71, 403 (1972); Chem. Abstr., 76, 98915^u (1972).
- 25. Pineau, J.P. and Chopin, J., Bull. Soc. Chim. France, (10), 3678 (1971).

- 26. Aubry, C. and Chopin, J., Bull. Soc. Chim. France, (12), 4503 (1971).
- 27. Bognár, R. and Litkei, G., Acta Chim. (Budapest), <u>67</u>, 83 (1971); Chem. Abstr., <u>74</u>, 99734^e (1971).
- 28. Dinya, Z. and Litkei, G., Magyar Kem. Folyoirat, <u>78</u>, 630 (1972); Chem. Abstr., <u>78</u>, 96974^e (1973).
- 29. Gormley, T.R. and O'Sullivan, W.I., Tetrahedron, <u>29</u>, 369 (1973).
- 30. Tishchenko, I.G., Burel, O.N. and Kononovich, V.I., Vestn.

  Beloruss, Gos. Univ., Ser. 1, 2(2), 28 (1969); Chem. Abstr.,

  75, 19466 (1971).
- 31. Bognár, R. and Litkei, G., Acta Univ. Debrecen. Ludovico

  Kossuth Nom., 8, 25 (1962); Chem. Abstr., 59, 13924^f (1963).
- 32. Chanda, B.K., Kar, J.N., Behera, G.B. and Rout, M.K., J. Indian Chem. Soc., <u>48</u>, **9**67 (1971).
- 33. Dinya, Z. and Litkei, G., Acta Chim. (Budapest), <u>77</u>, 211 (1973): Chem. Abstr., 78, 65571ⁿ (1973).
- 34. Orlov, V.D., Korotkov, S.A., Sukach, Y.A. and Lavrushin, V.F., Zh. Obshch. Khim., 43, 1353 (1973).
- 35. Dinya, Z., Litkei, G., Bognar, R. and Matyas, G., Magyar Kem. Folyoirat, <u>78</u>, 504 (1972): Chem. Abstr., <u>78</u>, 42310^S(1973).
- 36. Orlov, V.D., Korotkov, S.A., Sukach, Y.A. and Lavrushin, V.F., Khim. Geterotsikl. Soedin., (3), 306 (1975); Chem. Abstr., 82, 169880^r (1975).

- 37. Vereshchagin, A.N., Vul'fson, S.G., Donskova, A.I. and Savin, V.I., Doklady Akad. Nauk SSSR, <u>215</u>, 339 (1974); Chem. Abstr., <u>81</u>, 3258 (1974).
- 38. Arbuzov, B.A., Donskova, A.I., Vul'fson, S.G. and Vereshchagin, A.N., Izv. Akad. Nauk SSSR, Ser. Khim., (7), 1498 (1975); Chem. Abstr., <u>83</u>, 178111^p (1975).
- 39. Marsman, B. and Wynberg, H., J. Org. Chem., 44, 2312 (1979).

### CHAPTER - 18.2

# CHALCONE olimits, olimits -DIBROMIDES

### Reactions:

Synthesis	of Flavones
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### Reactions:

The reaction of substituted chalcone dibromides have been studied in considerable detail. Thus under varied experimental conditions the following types of compounds have been obtained

from chalcone dibromides viz., flavones, 1-23 flavonol, 24,28 flavanones, 29,30 aurones 2,7,8,10,11,22,24-26 benzoylcoumarones, 12 +bromochalcones, 22,31 tetralones, 33 aziridines 5,23 etc.

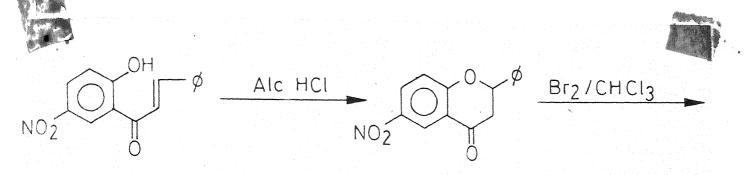
# Synthesis of Flavones 1-23:

Flavones have been secured either by the pyrolysis  3,9  of  $\underline{o}$ -hydroxy (or  $\underline{o}$ -acetoxy) chalcone  $\alpha$ ,  $\beta$  -dibromides or by their reaction with alcoholic alkali,  $^{2,5-13}$  sodium methoxide,  4  pyridine  $^{1,15-21}$  or potassium cyanide.  3,22  The latter reaction has been utilized  3  for the synthesis of naturally occurring flavones, containing a phloroglucinol nucleus, viz., chrysin, apigenin and luteolin.

In the conversion of o-substituted chalcone dibromide into the corresponding flavone, under the influence of a base, the

The formation of flavone from 2'-hydroxy-3-nitrochalcone dibromide has been rationalized⁸ in the following way:

In this case pyridine behaves like an alkali and brings about dehydrobromination and cyclisation. Nuclear substitution in this case is not feasible since the probable position of entry of the bromine is already occupied. Utilising this reaction some substituted flavones have been synthesized. 8-Nitro-7-hydroxylfavone has been prepared in the aforesaid manner. The isomeric compound viz., 5-hydroxy-6-nitroflavone, however, can be prepared as follows:



In the synthesis of flavones from chalcone dibromides and ethanolic alkali, it has been demonstrated that steric effects do play an important role. Thus flavone derived from chalcone (Ia) is obtained in 89% yield, while the flavone from chalcone (Ib) is secured in relatively low yield (46%).

(Ia) R=R'=R"=H; R"=Ac (b) R=R"=H; R'=Br; R"=Ac

In this reaction, aurone is also formed, but in smaller amounts. 13

A mixture of 2'-hydroxy-5'-methyl-4-methoxychalcone bromide (II) and 2'-hydroxy-5'+methylchalcone (III) is reported²³ to react in the presence of pyridine leading to the formation of cross brominated products (IV and V):

followed by oxidative cyclisation.

# Aurones 2,7,8,10,11,22,24,25,26:

2'-Hydroxy-4-nitrochalcone dibromide undergoes ring cyclisation under the influence of alkali, to yield the corresponding aurone. The following mechanism has been advanced⁸ for this reaction:

The anion the anion (VI). gets protonated and the aurone hydrobromide (VII) loses a molecule of HBr to form the aurone (VIII).

Flavones are generally obtained 7 from 2'-acetoxychalcone dibromides and dichlorides, having a substituent in 6'-position-Aurones, however, are formed when the dihalides carried

substituents both in 3'- and 6'-positions. Apparently steric effect plays an important part in the formation of aurone.

Aurones are produced along with flavones in the reaction of chalcone dibromides with alcoholic potassium cyanide²² or dilute alcoholic alkali.^{2,10,11} The ratio of aurone to flavone in the

# Benzoylcoumarone:

Some of the o-acetoxychalcones, on treatment with a base yield, the corresponding benzoylcoumarones. The following example is illustrative 12.

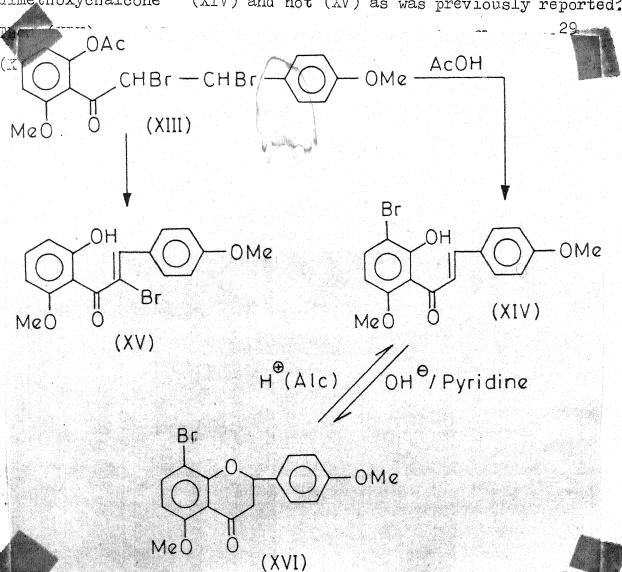
2',4'- Dihydroxy - 2 - benzoyl-Coumaro

The title compounds have been prepared from appropriately substituted chalcone dibromides. Flavonol, ²⁷ for example, is obtained by the reaction of o-acetoxy chalcone with alkali in aqueous-acetone medium:

It is postulated 28 that the aqueous-acetone replaces the &-bromine atom with the hydroxyl function and removes two hydrogen atoms.

#### Flavanones:

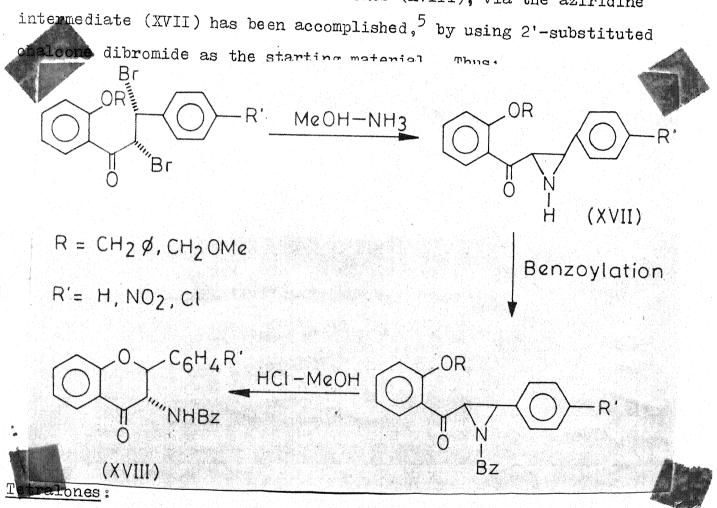
Treatment of 2'-acetoxy-4,6'-dimethoxychalcone dibromide with acetic acid results in deacetylation, debromination, nuclear amomination and the formation of 2'-hydroxy-3'-bromo-4,6-dimethoxychalcone (XIV) and not (XV) as was previously reported.



dromides can be transformed into a variety of products, viz., -bromochalcones, 22,31 aziridines and aminoflavanones. 4
bromochalcones are obtainable by dehydrobromination of chalcone

dibromides brought about by alcoholic potassium hydroxide. & chlorochalcones, however, can be obtained by dehydrochlorination with potassium acetate in absolute ethanol, 32

The preparation of aminoflavanones (XVIII), via the aziridine



Chalcone dibromides have been utilized as starting materials for the preparation of 2-aryl-1-tetralone³³ (XIX) by the following sequence of reactions:

COCH Br - CHBr - R² KCN R' COCH₂ CH (CN) R²

Hydrolysis R'COCH2CH (COOH)R2 Zn-Hg/HCI

R'CH2 CH2 CH (COOH) R2 POCI3

(R' and  $R^2$  are aryl groups) (XIX)

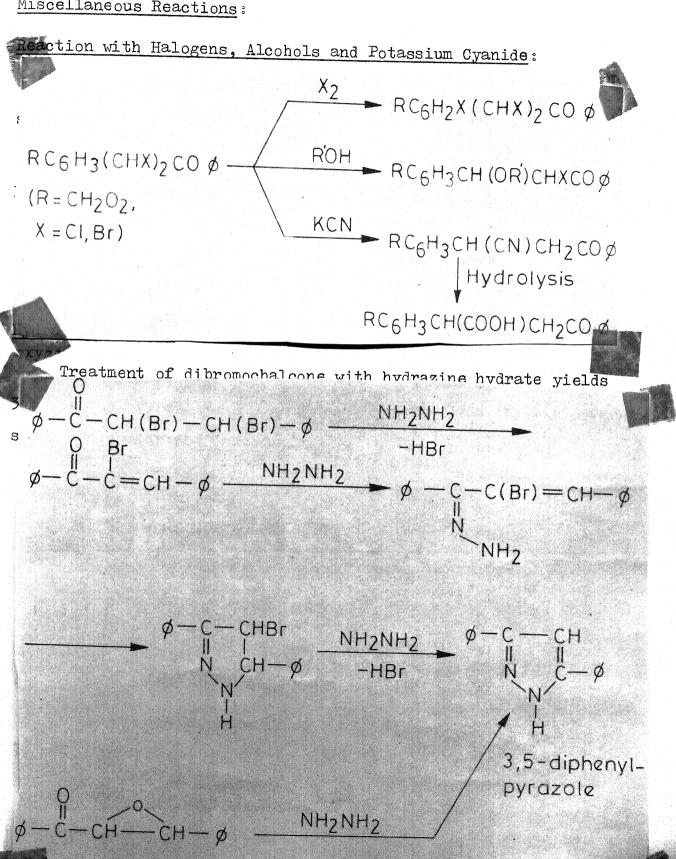
According to a patent, the synthesis of benzalacetone 34 has been effected by the reaction of chalcone dibromide with alkali crcaptide.

CAPTIGE. (CHBr)2-CO-Ø Na/MeOH, PrSH Ø CH=CH COM

# Aziridines^{35,36};

Aziridines have been prepared by reacting R'NH2 (R' = H, Me or Bz) with 4-nitrochalcone dibromide. 36 The following mechanism

### Miscellaneous Reactions:



### Sodium Azide³⁹:

2'-hydroxy (and 2'-benzyloxy) chalcone dibromides are reported 39 to react with sodium azide, leading to the formation of  $\mathcal{A}$ -azidochalcones.

### Cleavage of d -bromochalcone with HBr and Oxygen:

#### References

- 1. Wadodkar, P.N., Indian J. Chem., 1, 163 (1963).
- 2. Nadkarni, S.M., Warriar, A.M. and Wheeler, T.S., J. Chem. Soc., 1798 (1937).
- 3. Hutchinson, W.A. and Wheeler, T.S., J. Chem. Soc., 91 (1939).
- 4. Bhagwat, N.A. and Wheeler, T.S., J. Chem. Soc., 94 (1939).
- 5. Litkei, G., Bognar, R. and Ando, J., Acta Chim. (Budapest), 76, 95 (1973); Chem. Abstr., 79, 18533⁸ (1973).
- Litkei, G. and Bognár, R., Acta Phys. Chem. Debrecina, <u>17</u>,
   239 (1971); Chem. Abstr., <u>78</u>, 42970^g (1973).
- 7. Donnelly, J.A., Doran, H.J. and Murphy, J.J., Tetrahedron, 29, 1037 (1973).

- 8. Donnelly, D.J., Donnelly, J.A. and Philbin, E.M., Tetrahedron, 28, 1867 (1972).
- 9. Donnelly, D.J., Donnelly, J.A. and Philbin, E.M., Tetrahedron, 28, 53 (1972).
- 10. Donnelly, J.A. and Doran, H.J., Tetrahedron, 31, 1565 (1975).
- 11. Donnelly, J.A. and Doran, H.J., Tetrahedron, 31, 1791 (1975).
- 12. Tambor, J. and Gubler, H., Helv. Chim. Acta, 2, 101 (1919).
- 13. Donnelly, D.J., Donnelly, J.A., Murphy, J.J., Philbin, E.M. and Wheeler, T.S., Chem. Commun., (12), 351 (1966).
- 14. Chhaya, G.S., Trivedi, P.L. and Jadhav, G.V., J. Univ. Bombay, <u>27A</u>, Part 3, 26 (1958); Chem. Abstr., <u>54</u>, 8807⁶ (1960).
- 15. Seshadri, S. and Trivedi, P.L., J. Org. Chem., <u>23</u>, 1735 (1958).
- 16. Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 53 (1960); Chem. Abstr., <u>55</u>, 1598^e (1961).
- 17. Naik, V.G. and Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 55 (1960); Chem. Abstr., <u>55</u>, 1598^e (1961).
- 18. Naik, V.G. and Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 61 (1960); Chem. Abstr., <u>55</u>, 1599^a (1961).
- 19. Gore, K.G., Naik, V.G. and Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 65 (1960); Chem. Abstr., <u>55</u>, 1599⁶ (1961).
- 20. Gore, K.G., Naik, V.G. and Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 69 (1960); Chem. Abstr., <u>55</u>, 1599^h (1961).

- 21. Gore, K.G., Somaware, H.R., Thakar, G.P. and Marathey, M.G., J. Univ. Poona, Science & Technol., <u>18</u>, 73 (1960); Chem. Abstr., 55, 1600^c (1961).
- 22. Vandrewalla, H.P. and Jadhav, G.V., Proc. Indian Acad. Sci., 28A, 125 (1949).
- 23. Ghiya, B.J. and Marathey, M.G., Indian J. Chem.,  $\underline{6}$ , 766 (1968).
- 24. Khanolkar, A.P. and Wheeler, T.S., J. Chem. Soc., 2118 (1938).
- 25. Joshi, K.C. and Jauhar, A.K., Indian J. Chem., 1, 477 (1963).
- 26. Donnelly, D.J., Donnelly, J.A. and Keegan, J.R., Tetrahedron, 33, 3289 (1977).
- 27. Marathey, M.G., J. Univ. Poona, Science & Technol., No. 4, 73 (1953); Chem. Abstr., 49, 10944ⁱ (1955).
- 28. Marathey, M.G., Science & Culture, 16, 527 (1951).
- 29. Donnelly, J.A., Tetrahedron, 29, 2585 (1973).
- 30. Pendse, H.K., Rasayanam, 2, 131 (1956); Chem. Abstr., <u>51</u>, 5063^f (1957).
- 31. Sharma, T.C., Patel, H. and Bokadia, M.M., Indian J. Chem., 11, 703 (1973).
- 32. Brosche, K., Weber, F.G., Westphal, G. and Reimann, E., Z. Chem., 19, 96 (1979).
- 33. Hidayetulla, M.S., Shah, R.C. and Wheeler, T.S., J. Chem. Soc., 111 (1941).
- 34. Thompson, R.B., U. S. Patent 2,553,797 (1951); Chem. Abstr., 46, 7579^e (1952).

- 35. Tarburton, P., Wolpa, L.J., Loerch, R.K., Folsom, T.L. and Cromwell, N.H., J. Heterocyclic Chem., 14, 1203 (1977).
- 36. Weber, F.G. and Bandlow, C., Z. Chem., 13, 467 (1973).
- 37. Dodwadmath, R.P. and Wheeler, T.S., Proc. Indian Acad. Sci., 2A, 438 (1935); Chem. Abstr., 30, 1770⁹ (1936).
- 38. Sharma, T.C., Saxena, M.K. and Bokadia, M.M., Indian J. Chem., 9, 794 (1971).
- 39. Patonay, T., Rakesi, M., Litkei, G., Mester, T. and
  Bognar, R., Flavonoids Bioflavonoids, Proc. Hung. Bioflavonoid
  Symp., 5th, 227 (1977); Chem. Abstr., 89, 108954^r (1978).
- 40. Kasiwagi, V.H., Bull. Chem. Soc. Japan, 26, 355 (1953).

#### CHAPTER - 19

#### USES

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Many patents have appeared in the literature describing the usefulness of chalcones and their derivatives. Thus these find application as artificial sweeteners, ¹⁻²⁰ stabilizer ²¹⁻⁴⁰ against heat, visible light, ultraviolet light, ageing; colour photography, ⁵⁵ scintillators, ⁶⁵ polymerisation catalyst, ^{68,69} fluorescent whitening agents, ⁷⁰ organic brightening additives ^{71,72} etc.

### Sweeteners 1-20:

Chalcone derivatives, viz., Dihydrochalcones and their corresponding glycosides have been employed as food sweetening agents. Dihydrochalcone xylosides and galactoside, 3,3,10 for example, are claimed to be 1.5-2 times sweeter than saccharin. Incorporation of cylodextrin with the sweetener-neohesperidin dihydrochalcone, 3,7 is reported to stabilize its aqueous solution. The preparation of a mixture of glucosides, 3,8,9 (mono-, di-, tri-, tetra- and penta) of hesperidin dihydrochalcone has been described. 3,2',4',6'-Tetrahydroxy-4-propoxy-dihydrochalcone-4  $\beta$  '-neohesperdoside has been used as a synthetic sweetener and is 2,200 times sweeter than glucose.

### Stabilizers:

2',4-Dihydroxy-3,5-di-<u>tert</u>.butylchalcone has been employed as an oxidation inhibitor²¹ and stabiliser²² to polyproplene polymer.

Hydroxychalcones form the starting material for the preparation of hydroxyflavones which serve as antioxidants for lipoid material. ²³

Chalcone is a natural constituent of beer and plays, in combination with other polyphenols, an important role in its stability. 24

Chalcone forms the constituent of corrosion inhibiting lubricants²⁵ suited for internal combustion engines containing silver and similar metal components. According to one patent²⁶

the efficiency of lubricant additive is retained by incorporation of chalcone, otherwise it is diminished by reaction of the additive with olefinic components of base oils or grease.

The incorporation of 2',4,4'-trimethoxychalcone into pulp sheets (on which pesticide was absorbed) helped in retarding the air degradation. ²⁷

It has been reported ²⁸ that the addition (upto 5%) of chalcone to poly (dimethoxysiloxane)— the silicone dielectric fluid, for impreganation of capacitors etc. improves its dielectric life. Chalcone ²⁹ and β -(benzoyloxy)-2'-hydroxy-chalcone ³⁰ have proved to be good light absorbers and heat stabilizers for polymeric materials, viz., polymethyl methactriate film and PVC resin sheets. Organic esters having chalcone type skeleton, viz., RC₆H₃(OH)COCH=C(OOCC₆H₅)C₆H₅ where R=Br or H have been employed for the aforesaid purpose. ³¹

Incorporation of 0.02-5% chalcone is claimed to prevent discoloration of microcrystalline petroleum waxes³² and polymers³³ (halogen containing polyvinyl compounds) exposed to sunlight. Likewise polyolefins are stabilized³⁴ against light, heat as well as ageing by adding small amount of chalcone.

Chalcone has been described to possess uv absorption property and hence finds application as uv absorption filters. 35,36

Chalcone serves as a suitable ultraviolet absorption additive 37 in adhesives, lacquers and plastics.

선물 보다 한 경험 사람들이 얼마를 받는 것들이 되었다. 그렇게 되었다는 것은 사람들이 되었다.

A non-irritating preparation containing 1-5% chalcone, for the protection 38,39 of skin from sunlight, has been patented.

It is reported⁴⁰ that the properties of cellulosic material are improved with ionization radiations in the presence of graftable organic finishing agent, consisting of chalcone and a sensitizer.

#### Photosensitive Materials:

A number of chalcone derivatives 22,41-47 form the principle ingradients in the preparation of photosensitive polymeric material, some of which possess good film forming properties. 42

Photocross linkable copolymers⁴⁸ are used for the preparation of sharp relief images and printing blocks, printing of multilayer circuits.⁴⁹ The printed image in the latter case is claimed to be of high edge sharpness.

Light sensitive preparations useful for printing plates of improved sensitivity and resolution are described 50-53 which, for example, involve the reaction of 4'-(2-hydroxyethoxy) chalcone with styrene-maleic anhydride copolymer under appropriate conditions.

Another light sensitive resin has been reported⁵⁴ which possesses good characteristics in respect of adhesion, toughness, alkali resistance and stability towards oxidation. The resin has been obtained⁵⁴ by heating 3,4'-dihydroxychalcone with an epoxyresin in a suitable solvent, in the presence of alkali.

Chalcone, 4-isocyanato chalcone and furan analogue of chalcone have proved useful in the preparation of light sensitive film used in colour photography. 55 Chalcone is also used in the preparation of photo-thermographic emulsion. 56

4,4-Diphenylaminochalcone⁵⁷ and 4,4'-<u>bis</u> (diphenylamino) chalcone^{58,59} have been used as constituents of a photoconducing composition for use in electro-photographic products.

Photographic silver halide emulsion spectrally sensitized with carbocyanine dyes, can be supersensitized with some chalcones, viz., 2' (and 4')-chlorochalcones.

### Polymers:

Dihydroxychalcone has been used for the preparation of uncured epoxyresins. 4,4'-Dihydroxychalcone forms the component of a duroplastic mixture, which possessess good mechanical properties and a high thermal stability.

Methacrylogyloxychalcones are used as cross linking agents ⁶⁴ in the preparation of butyl acrylate-styrene copolymers, which are claimed ⁶⁴ to be useful as lacquers.

### Scintillators:

2,4,6-Trisubstituted pyridines, derived from chalcones and formamide (Leuckart reaction), exhibit extremely intense fluorescence and could be used as ascintillators. 65

### Analytical Reagents:

Chalcones react with a number of metal ions and are reported  66  to be more reactive than the aldehyde or ketone from which they have been prepared. This reaction has been exploited  67  for the detection of Fe⁺⁺⁺ (limit of identification: 0.33  $\Upsilon$ /0.05 ml) by 2',4'-dihydroxychalcone, provided the concentration of interferring ions is kept at a minimum.

### Miscellaneous Applications:

# Polymerisation Catalysts, Fluorescent Whitening Agents and Organic Brightening Additives:

Chalcone is reported^{68,69} to form a component of a polymerisation catalyst designed for obtaining a highly crystalline polyolefinic polymers, viz., polyacrylates, in high yields.

Chalcone sulphonic acids serve as intermediates in the preparation of fluorescent whitening agents. Chalcones have also been employed as organic brightening additives.

### References

- 1. Linke, H.A.B. and Eveleigh, D.E., Z. Naturforsch., 30B, 740 (1975).
- Horowitz, R.M. and Gentili, B., U.S. Patent, 3,890,298
   (1975); Chem. Abstr., 83, 147706^g (1975).
- Horowitz, R.M. and Gentili, B., U.S. Patent, 3,890,296
   (1975); Chem. Abstr., 83, 147703^d (1975).

- 4. Rizzi, G.P. and Neely, J.S., German Patent, 2,148,332 (1972); Chem. Abstr., 77, 86777h (1972).
- 5. Fukomoto, J. and Okada, S., German Patent, 2,204,716 (1972);
  Chem. Abstr., 77, 152515^Z (1972).
  Sweetness
- 6. Horowitz, R.M. and Gentili, B.,/Sweeteners, Proc. Ind. Univ. Co-op. Symp., 69 (1971); Chem. Abstr., 78, 56483ⁿ (1973).
- 7. Robertson, G.H., Clark, J.P. and Lundin, R., Ind. Eng. Chem., Prod. Res. Develop., <u>13</u>, 125 (1974); Chem. Abstr., 81, 37745 (1974).
- 8. Horowitz, R.M. and Gentili, B., U.S. Patent, 3,429,873 (1969); Chem. Abstr., 70, 87315 (1969).
- 9. Laboratoires Coupin (S.A.), French Patent, 1,221,869 (1960); Chem. Abstr., <u>56</u>, P 10046 (1962).
- 10. Horowitz, R.M. and Gentili, B., U.S. Patent 3,876,777 (1975); Chem. Abstr., 83, 28539 (1975).
- 11. Hashimoto, S. and Katayama, A., Japanese Patent 7,535,349 (1975); Chem. Abstr., <u>83</u>, 7607^a (1975).
- 12. International Minerals and Chemical Corpn., British Patent 1,189,573 (1970); Chem. Abstr., 73, 45798 (1970).
- 13. Chen, C.I., Lin, Y-Y and Lin, Y-C., T'ai-wan K'o Hsueh, 28, 40 (1974); Chem. Abstr., 83, 42971^m (1975).
- 14. Lindner, K., Czelenyi, C., Kubat, K., Bolla, F. and Szejtli, J., Acta Aliment. Acad. Sci. Hung., 6, 311 (1977); Chem. Abstr., 88, 103430^m (1978).

- 15. Antus, S., Farkas, L., Gottsegen, A., Nogradi, M., Strelisky, J. and Pfliegel, T., Acta Chim. Acad. Sci. Hung., 98, 231 (1978); Chem. Abstr., 90, 121124^k (1979).
- 16. Antus, S., Farkas, L., Gottsegen, A., Nogradi, M. and Pfliegel, T., Acta Chim. Acad. Sci. Hung., <u>98</u>, 225 (1978); Chem. Abstr., <u>90</u>, 86935^b (1979).
- 17. Linke, H.A.B. and Eveleigh, D.E., U.S. Patent 4,087,558 (1978); Chem. Abstr., 89, 90260^Z (1978).
- 18. Kamiya, S., Ezaki, S., Konishi, F. and Watanable, T.,

  Japan Kokai, 7837,646 (1978); Chem. Abstr., <u>89</u>, 110284^r

  (1978).
- 19. Kamiya, S., Konishi, F. and Ezaki, S., Agric. Biol. Chem., 42, 941 (1978).
- 20. Yamato, M., Hashigaki, K., Mito, K. and Koyama, T., Chem. Pharm. Bull, <u>26</u>, 2321 (1978); Chem. Abstr., <u>90</u>, 22748^k (1979).
- 21. Adams, J.H., British Patent, 1,250,388 (1971); Chem. Abstr., 76, 46956^p (1972).
- 22. Akhmedzade, D.A., Yasnopol'skii, V.D. and Golovanova, Y.I., Azerb. Khim. Zh. (2), 117 (1968); Chem. Abstr., 69, 107333ⁿ (1968).
- 23. Simpson, T.H. and Uri, N., British Patent, 875,164 (1956); Chem. Abstr., <u>56</u>, p 3582^b (1962).
- 24. Karel, V., Brauwissenschaft, <u>14</u>, 411 (1961); Chem. Abstr., <u>56</u>, 5220^a (1962).

- 25. Fields, E.K., U.S. Patent 2,799,652 (1957); Chem. Abstr., 51, 15113° (1957).
- 26. Bayer, F., German Patent 919,128 (1954); Chem. Abstr., 52, 13244ⁱ (1958).
- 27. Aries, R., French Patent 2,129,811 (1972); Addn. to French Patent 2,096,713; Chem. Abstr., 78, 120265 (1973).
- 28. General Electric Company, German Patent, 1,106,821 (1961); Chem. Abstr., <u>57</u>, 5460ⁱ (1962).
- 29. Gunder, O.A., Vlasov, V.G., Koval, L.N. and Krasovitskii, B.M. (U.S.S.R.), Plast. Massy (6), 3 (1968); Chem. Abstr., 69. 36699^y (1968).
- 30. Buckman, S.J., Flanagan, K.J., Pera, J.D. and Wienert, L.A., U.S. Patent 3,629,322 (1971); Chem. Abstr., 76, 114277 (1972).
- 31. Buckman, S.J., Flanagan, K.J., Pera, J.D. and Wienert, L.A., S. African Patent 6902,541 (1969); Chem. Abstr., 72, 122440^a (1970).
- 32. Rumberger, G.G., U.S. Patent 2,755,193 (1956); Chem. Abstr., 50, P 16101⁶ (1956).
- 33. Chemische werke Huls G.m.b.H., British Patent, 710,964 (1954); Chem. Abstr., 49, 668 (1955).
- 34. Bonvicini, A., "Montecantini", Societa Generale per 1' industria' Mineraria e chimica. Italian Patent, 662,500 (1964); Chem. Abstr., 63, 1950° (1965).
- 35. Ikeda, H. and Toba, K., Repts. Govt. Chem. Ind. Research Inst., Tokyo, <u>51</u>, 65 (1956); Chem. Abstr., <u>50</u>, 11110ⁱ (1956).

- 36. Ikeda, H. and Toba, K., J. Soc. Sci. Phot. Japan, <u>18</u>, 110 (1956); Chem. Abstr., <u>51</u>, 2395^e (1957).
- 37. Stecher, H., Adhasion, 2, No. 6, 243 (1958); Chem. Abstr., 53, 14579^c (1959).
- 38. Giese, A.C., Christensen, E. and Jeppson, J., J. Am. Pharm Assoc., 39, 30 (1950); Chem. Abstr., 44, 3209^b (1950).
- 39. Fischer, F., Schuchhardt, W. and Walter, H., East German Patent 69,672 (1969); Chem. Abstr., 73, 7093^y (1970).
- 40. Munzel, F., U.S. Patent, 3,254,939 (1966); Chem. Abstr., 65, 7358^b (1966).
- 41. Hatanaka, H., Sugiyama, K., Nakaya, T. and Imoto, M., Mikromol. Chem., <u>176</u>, 3231 (1975); Chem. Abstr., <u>84</u>, 31790^W (1976).
- 42. Ichibashi, T. and Kawai, W. Japanese Patent 7414,352 (1974 Chem. Abstr., 82, 17466 (1975).
- 43. Ichibashi, T. and Kawai, W., Japanese Patent 7501,191 (197 Chem. Abstr., 83, 35721b (1975).
- 44. Kato, M., Hasegawa, M. and Ichijo, T., U.S. Patent, 3,873, (1975); Chem. Abstr., 83, 29065^Z (1975).
- 45. Nakane, H., Ichii, K., Ayabe, T. and Asaumi, S., Japanese Patent 7239,184 (1972); Chem. Abstr., <u>78</u>, 112129^r (1973).
- 46. Panda, S.P., J. Appl. Polymer. Sci., 18, 2317 (1974).
- 47. Panda, S.P., J. Armament Studies, 11, 30 (1975).
- 48. Ehrig, B., Mueller, E., Mott, L. and Wolf, E., German
  Patent 2,116,010 (1972); Chem. Abstr., 78, 17120^X (1973).

- 49. Zahir, S.A.C., Rembold, H. and Losert, E., German Patent 2,342,407 (1974); Chem. Abstr., <u>81</u>, 113724^e (1974).
- 50. Smith, A.C. (Jr.), Williams, J.L.R. and Unruh, C.C., U.S. Patent, 2,816,091 (1957); Chem. Abstr., 52, P 4369^a (1958).
- 51. Munder, J., Ruckert, H., Steppan, H., Messwarb, G. and Lueders, W., (Kalle A-G), S. African Patent 6804,327 (1969); Chem. Abstr., 71, 86597^a (1969).
- 52. Kalle, A-G., French Patent 1,573,500 (1969); Chem. Abstr., 72, 138327^e (1970).
- 53. Kato, M., Ichijo, T., Ishii, K. and Hasegawa, M., J. Polymer Sci., Part A-1, 9, 2109 (1971).
- 54. Atkinson, R.B., U.S. Patent 3,410,824 (1968); Chem. Abstr., 70, 20691^Z (1969).
- 55. Schellenberg, W.D. and Heinz, J., Farbenfabriken Bayer
  Akt.-Ges., German Patent 1,039,835 (1959); Chem. Abstr.,
  55, 7119^f (1961).
- 56. Gunther, M. (Agfa Akt.-Ges.), German Patent 1,047,013 (1958); Chem. Abstr., 55, 8137^f (1961).
  - 57. Fox, C.J. (Eastman Kodak Company), British Patent 1,143,340 (1969); Chem. Abstr., 70, 92292^t (1969).
  - 58. Contois, L.E. and Merrill, S.H., French Patent 2,016,435 (1969); Chem. Abstr., 74, 93486^d (1971).
  - 59. Contois, L.E. and Specht, D.P., French Patent 2,022,355 (1970); Chem. Abstr., 74, 133060^u (1971).
- 60. Yamaguchi, H. and Aoki, K., Nippon Shashin Gakkai Kaishi, 20, 10 (1957); Chem. Abstr., <u>53</u>, 107^d (1950).

- 61. Panda, S.P., Indian J. Technol., 9, 387 (1971).
- 62. Panda, S.P., Indian J. Technol., 11, 356 (1973).
- 63. Koelbel, H., Manecke, G. and Guettler-Pimenidou, E., German Patent 2,256,961 (1974); Chem. Abstr., 82, 73919^j (1975).
- 64. Ehrig, B., Mueller, E. and Mott, L., German Patent 2,013,414 (1971); Chem. Abstr., 76, 86380^c (1972).
- 65. Delcarmen, M., Barrio, G., Barrio, J.R., Walker, G., Novelli, A. and Leonard, N.J., J. Am. Chem. Soc., <u>95</u>, 4891 (1973).
- 66. Lense, F.T., Glover, C.A. and Markham, E.C., Virgina J. Sci., 3, 14 (1942); Chem. Abstr., 36, 31139 (1942).
- 67. Syamasundar, K., Proc. Indian Acad. Sci., 59A, 241 (1964).
- 68. Mitsubishi Petrochemical Co. Ltd., British Patent 1,128,090 (1968); Chem. Abstr., 69, 97342^y (1968).
- 69. Hercules Powder Co., British Patent, 873,021 (1959); Chem. Abstr., <u>56</u>, 6185^h (1962).
- 70. Hayakawa, G. and Inoue, T., Japanese Patent 7107,386 (1971); Chem. Abstr., <u>74</u>, 143332^y (1971).
- 71. Phillip's N.V., Gloeilampenfabrieken, Netherland Patent 6,501,841 (1966); Chem. Abstr., 66, 16034ⁿ (1967).
- 72. Baeyens, P. and Krijl, G., Trans. Inst. Metal. Finish, 45, 115 (1967); Chem. Abstr., 67, 104540^a (1967).

## Author Index

The numbers in parentheses are the reference numbers.

Abbe, N.J.V.

Abbott, U.K.

Abdalla, M.

Abdel-Halim, M.S.

Abdel-Maksoud, A.

Abdel-Megeid, E.M.F.

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2'-Acetoxychalcone  $\mathcal{L}$ ,  $\beta$  -dichlorides

Acetylacetone

6-Acetyl-5,8-dihydroxy-2,2-dimathoxychromene

Acrylate-styrene copolymers

Acrylyl chloride

Acyl carbenes

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1,4-addition

Adhesives

Air degradation

Aliphatic nitriles

Alkali metal borohydride

Alkali sulphide

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Amberlite

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& -Arylchalcone

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Benzofuranones, diastereoisomeric

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Benzylamine

Benzyl-p-tolyl sulphone

Benzylic carbonium ion

Benzylidene acetophenone

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2'-Benzyloxy-4,4'-dimethoxy chalcone

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2'-Benzoyloxy-4-methoxy-1-hydroxy-1-ethoxy dihydrochalcone

1-(2-benzyloxyphenyl)-2-hydroxy-3-chloro (p-methoxyphenyl)-propan-1-one

Berberine

Betaine like methylene triphenylphosphorane

Bicyclic analogue of chalcone

Bicyclic keto alcohol

Bimolecular compounds

Bimolecular products

Bis adduct

4,4'-bis (diphenylamino) chalcone

N,N-bis ( phenacylbenzyl) methylamine

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d -Bromo-β -methoxy-β -phenyl propiophenone

 $\ll$ -Bromo- $\beta$ -propoxychalcone

trans-1 -Bromomethylchalcone

1-Bromo-2-methyl-2-imidazoline

N-Bromomorpholine

N-Bromosuccinimide

Butein

Butin

Tert. butyl hydroperoxide

n-Butyl magnesium bromide

Butyric ester

Calcium hydride

Camphor

4- Carbethoxychalcone

∠ -Carbethoxy- β -phenyl- Y-benzoyl butyric ester

Carbinol

Carbocyanine dyes

Carbonium ion

Carbon monoxide

Carbonyl stretching frequency

Carbonyl ylides

Carboxychalcones

Carboxylic acid derivative of chalcones

Catalysed oxidation

Catalytic hydrogenation, PtO₂

Chalcol

Chalcone

Cis-chalcone

trans-chalcone

Chalcone analogues of:

Acridine

Anthracene

Benzochrotrene

1,4-Benzodioxans

Caffeic acid

Carbazole

Cymantrene

Ferrocene

Furan

8-Hydroxyquinoline

Indole

Naphthalene

Phenanthrene

Piperidine

Pyrazole

Pyridine

Pyridone

Pyrrole

Quinoline

Golomophene

Thiophene

Chalcone complexes (1:1)

Chalcone complexes with antimony pentachloride

boric acid

ferric chloride

Chalcone derivatives

Chalcone &, p-dibromides

Chalcone  $\mathcal{A}$  ,  $\beta$  -dichlorides

Chalcone & , & -dichlorides, stereoisomeric

Chalcone dimers

Chalcone-2,4-dinitrophenylhydrazone

 $\underline{t}$ -Chalcone epoxide

t-Chalcone epoxide, absolute configuration of,

Chalcone-flavanone isomerase

Chalcone glucoside

Chalcone glycoside

Chalcone hydrosulphide

Chalcone-metanil indicator

Chalcone oxime, trans.

Chalcone syn-oxime

Chalcone phenylsemicarbazone

Chalcone semicarbazone

Chalcone sulphonamide

Chalcone sulphonic acid

Chalcone thiosemicarbazone

Chalcononaringenin-4-glucoside

Chalols

Chelation

Chiral crystals

Chlorine

Chlorine thiocyanate

d-Chlorochalcone

4-Chlorochalcone

2'-Chlorochalcone

4'-Chlorochalcone

5-(4-Chlorocinnamoyl) salicyclic acid

2'-Chloro-4,4'-difluorochalcone

6-Chloro-1,3-dihydroxy-2-phenylquinolin-4 (1H)-one

Chlorohydrin

Chlorohydroxychalcone

4-Chloro-4'-hydroxy-5'-carboxychalcone

 $\angle$  -Chloro- $\beta$ -methoxy- $\beta$ -phenylpropiophenone

4-Chloro-5'-methyl-2-thioalkyl chalcone

3-Chloro-2'-nitrochalcone

N-chlorosulphonyl-4,6-diphenyl-2-oxo-3,5-dihydro-1,3-oxamine

Chlorosulphonylisocyanate

Cholinesterase

Chromanones

Chromenes

Chromenochalcone

Chromic acid

Chromogenic reagent

Chromophoric group

Chromous chloride reduction

Chromous salt

Chrysene

Chrysin

Cinnamic acid, substituted

Cinnamoyl chalcone

5-Cinnamoyl salicyclic acid

Cinnamoylidene acetophenone

4-Cinnamylidene-2,5-cyclohexadien-1-one

Cisoid conformation

Claisen-Schmidt reaction

Cleavage of C1 -C oxirane bond

Cleavage reaction

Clemmensen reaction

Cobalt chloride

Column chromatography

Colour photography

Colour reaction

Complex metal hydride

Complexing action of 2,2'-hydroxychalcone on Sn (IV) salts

Complexometric titration

Condensing agents

Aluminium chloride

Aqueous alkali

Boron trifluoride

Hydrogen chloride

Piperidine

Sodium methylate

Conductometric method for the estimation of copper

Conformation

Conjugate addition

Conjugation

Cordoin

Coumaran-3-one

Coumarinochalcone

Coumestrol

Cross bromination products

Cross linking agents

Crystallography

Cuprous chloride

Cyanoacetamide

Cyanocobalt complex

1-Cyano-2-methyl-2-aminoethylene

Cyanomethylchalcone

3-Cyano-4-phenyl pyridine

Cyclisation

Cyclisation of 2'-hydroxychalcone epoxide

Cycloaddition

Cyclodextrin

Cyclohexylamine-iodine complex

trans-1-Cyclohexyl-2-phenyl-3-benzoylethylene-immine

Cyclopentanone

Cyclopropane derivative

Cyclopropenes, substituted

Cystein

Darzen's condensation

Davidigenin and 4'-methoxy derivative

Davidioside

Deacetylation

Debromination

Decarbethoxylation

Degradation

Dehydration

Dehydrobromination

Dehydrochlorination

Dehydrohalogenation

Demethylation, partial

Deoxybenzoin

Derricidin

Derricin

Deuterium isotope

Dialkylamino alkoxy derivative of chalcone

3,5-Diaryl-4-hydroxy-△²-pyrazoline

Diastereoisomeric diketones

Diazomethane

Dibenzalacetophenone disulphide

Dibenzaltriacetophenone

1,4-Dibenzoyl-2,3-diphenylbutane

Dibenzoylmethanes

Dibenzyl diacetophenone

d, ₿ -Dibromochalcone

4,4'-Dibromochalcone

3,5-Dibromo-2,2'-dihydroxychalcone

1,3-Dibromo-5,5'-dimethylhydantoin

4',5-Dibromo-2-hydroxychalcone

N,N-Dibromosulphonamide

Dibutyl ether

4,4'-Dichlorochalcone epoxide

Dichloroethane

2,4-Dichlorophenoxyacetic acid

Dicyclohexylpropane

3',7-Diethoxy-2',4'-dimethoxyisoflavone

Diethylamine

2-Diethylaminoethyl mercaptan

3-Diethylaminopropyl mercaptan

1,1-Diethylamino-prop-1-yne

1,1-Diethyl-2-benzoyl-3-phenylcyclobutane

Diethyl-1,4-dihydro-2,6-dimethylpyridine-3,5-dicarboxylate

(see Hantzsch Ester)

3',7-Diethyoxy-2',4'-dimethoxyisoflavone

9,10-Dihydroanthracene

Dihydrochalcone

Dihydrochalcone galactoside

Dihydrochalcone xyloside

## Dihydroisoxazole

Dihydro pyrazole

Dihydro resorcinol

4',6-Dihydroxyaurone

2',4-Dihydroxy-3,5-tert. butylchalcone

3,4-Dihydroxy-3'-carboxychalcone

Dihydroxychalcone

2,2'-Dihydroxychalcone

2,4-Dihydroxychalcone

3,4-Dihydroxychalcone

4,4'-Dihydroxychalcone

2'.3-Dihydroxychalcone

2',4'-Dihydroxychalcone

2',4'-Dihydroxy-dihydrochalcone

2'.4'-Dihydroxy-3'.6'-dimethoxychalcone

2',4'-Dihydroxy-4',5'-dimethoxychalcone

4'.7-Dihydroflavanone

4',7-Dihydroflavonol

2',4'-Dihydroxy-3-methoxychalcone

2',4'-Dihydroxy-6-methoxychalcone

2',6'-Dihydroxy-4'-methoxy-3,5'-dimethyl dihydrochalcone

4,4'-Dihydroxy-2'-methoxychalcone

2'.6'-Dihydroxy-3'-methyl-4'-methoxychalcone

Dihydroxy phenylalanine carboxylase

2,2'-Dihydroxy-3,5,5'-tribromochalcone

2',4-Dihydroxy-4',5',6'-trimethoxychalcone

Diketones

Dimeric monocarboxylic acid

Dimerides

Dimerisation

Dimers

2,4-Dimethoxybenzoic acid

4,4'-Dimethoxy chalcone

4,4'-Dimethoxy chalcone epoxide

4,4'-Dimethoxy- $\beta$ -hydroxychalcone

Dimethyl acetylene diacarboxylate

4-Dimethylaminochalcone

2-(2-dimethylaminoethoxy) chalcone

2-(2-dimethylaminoethoxy)3',4',5'-trimethoxy-chalcone hydrochloride

4-Dimethylamino chalcone

4,4'-Dimethylchalcone

5,5%-Dimethylcyclohexan-1,3-dione

3,5-Dimethyl-4-nitroisoxazole

 $(\underline{\cdot})$  di-O-methyl pinobankin

Dimethyl sulphonium methylide

Dimethyl sulphoxonium methylide

gem-Dinitroalkane

2,4-Dinitrophenylhydrazine

2,4-Dinitrophenylsemicarbazide

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Dioxoles
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3,5-Diphenyl-1-acetamido-2-pyrazoline

4-Diphenyl aminochalcone

2,4-Diphenyl-6,7-benzo-1-thia-5-aza-4,6-cycloheptadiene

Diphenyl beryllium

2,4-Diphenyl-5 (or 1)-isopropyl-8 (or 6) methyl-9-keto-4-hydroxy-bicyclononane

3,5-Diphenylisoxazoline

Diphenyl ketene quinoline

Diphenyl mercury

- Diphenyl- - methoxyphenyl- - benzoyl-butyric ketone

1,3-Diphenyl-3-(2-nitro-1,3-indandion-2-yl)-1-propanone

1,3-Diphenyl-1,2-propandiol

1,3-Diphenylpropane

1,3-Diphenylpropanol

1,3-niplieny1-1-propanol

1,3-Diphenyl-2-propanol

1,3-Diphenyl-prop-1-ene

1,3-Diphenyl-2-propen-1-ol

1,3-Diphenyl-propen-1-one

□ - B '-Diphenylpropiophenone (3,3-Diphenyl propiophenone)

1,3-Diphenyl propyl alcohol

1,3-Diphenyl-1-propyn-3-one

3,5-Diphenyl-1-pyrazoline

Diphenyl styryl carbinol

3,5-Diphenyl-1-thioacetamido-2-pyrazoline

.phenyl tin hydride
.pole moment
3-Di (2-pyrryl) propenone
.ol
.sproportionation
.sodiophenone
,N-Disubstituted-2-(\omega-aminoalkoxy)-3',4',5'-trimethoxychalcone
.opping mercury electrode
.opping mercury electrode
.opping mercury electrode
.opping mercury electrode

Lectrode reduction
Lectrolytic reduction
Lectron bombardment
Lectronic absorption spectra, heterocyclic chalcone analogues
Lectrophotographic products
Lectrophilic attack
Lectrophilic hydroxylating system
nol tautomer
nzymatic transformations
poxidation
poxide ring opening, mechanism of
poxy resins
quilibrium

Eriodictin

Erythro and threo

Erythro chalcone dihalides

\$-Ethoxy chalcone

2-Ethoxy chalcone

2-Ethoxyflav-3-one

Ethyl acetoacetate

Ethyl-&-acetyl-B-phenyl-Y-benzoyl-butyrate

Ethyl alkyl malonate

Ethyl benzoyl acetate

p'-Ethylchalcone

Ethyl cyanoacetate

Ethyl-d-cyanobutyrate

Ethyl- -cyano- $\beta$ -Y-diphenylbutyrate

Ethyl magnesium bromide

Ethyl phenyl acctate

Ethyl thioglycolate

Ethylene diamine tetraacetic acid

Ethylene glycol

Ethylene imine ketone

Ethynyl carbinol

Eutectic

Extinction coefficient

Fenchone

Ferric chloride

Ferrocene analogue of chalcone

Ferrous sulphate

Flavan

trans-2,3-cis-3,4-flavandiol

Flav-3-ene

Flavanols

Flavanones

Flavanonols

Flavone

Flavones

Flavonoid biosynthesis

Flavonoids

Flav-3-ol

Flavanols

Flavylium salts

Flemi-chapparin-A

Fluoboric acid

Fluorescence

Fluorescence, quenching of

Fluorescent adsorbent

Fluorescent whitening agent

Fluorometric method

2-Fluoro-3-nitro-4-chalconyl-6-phenyl-acetamido penicillanate

Formation constant

Friedel Crafts alkylation

Fries migration

Furan analogues of chalcone

Go -Furfuylacetophenone

Gauche conformation
Geometric isomerism
Geometric isomers
Grignard reagents
Ground state

Halochromic effect
Haloform type cleavage
Halogenation
Halogenation, nuclear
Hammett constant
Hammett substitution constant

Hantzsch ester (see Diethyl-1,4-dihydro-2,6-dimethylpyridine-3,5-dicarboxylate)

Hantzsch-Werner hypothesis

Hesperidin

Hesperidin chalcone

Hesperidin dihydrochalcone glucoside

Hesperidin methylcarboxychalcone

Hesperidin methyl chalcone

Hesperatin chalcone

Heterocyclic analogue of chalcone

Heterocyclic epoxychalcones

Hexyl resorcinol

Homoflemingin

Homogeneous hydrogen transfer

Homologation of chalcone

Hop extract

Horse raddish peroxidas 3

Huckel's molecular orbital method

Huckel molecular orbital calculation

Hydrazine

Hydrazoic acid

Hydrazone

Hydride ion acceptor

Hydrochalcols

Hydrocyanic acid

Hydrogen

Hydrogen bonding, intermolecular and intramolecular

Hydrogen bromide, in the presence of oxygen

Hydrogen chloride in ether

Hydrogen donor

Hydrogen peroxide

Hydrogen peroxide, alkaline

Hydrogen sulphide

Hydrogenation, catalytic

Hydrogenation (Palladium-carbon catalyst)

Hydrogenation, selective

Hydrogenolysis

Hydrostannation

2-Hydroxyacetophenone

p-Hydroxybenzaldehyde

Hydroxybenzalcoumaranone

p-Hydroxybenzoic acid

2(o-Hydroxybenzoyl)-1-phenylethane sulphonic acid

2'-Hydroxy-3'-bromo-4,6'-dimethoxy chalcone

2'-Hydroxy-3'-bromo-4-methoxy-5'-methylchalcone oxime

2-Hydroxy-4-n-butoxy acetophenone

2'-Hydroxy-4'-carbethoxychalcone

4'-Hydroxy-5-carbethoxychalcone

2-Hydroxy-2'-carboxylic chalcone

Hydroxychalcones

Hydroxychalcone glycoside

3-Hydroxychalcone

o-Hydroxychalcones

cis-2-Hydroxychalcones

trans-2-Hydroxychalcone

o-Hydroxychalcone &, } -dibromide

- 2'-Hydroxy chalcone
- 2'-Hydroxychalcone sulphonic acid
- -Hydroxychalcone
- /3 -Hydroxychalcones
  - 4'-Hydroxychalcone
  - 4-Hydroxy cordoin
  - 4-Hydroxy derricin
  - 4'-Hydroxy-3',5'-diiodo-4-propoxy (and 4-butoxy) chalcone
  - 2'-Hydroxy-4',6'-dimethoxychalcone 4-glucoside
  - 2-Hydroxy-3,4-dimethoxy-3',4'-methylenedioxy chalcone
  - 2'-Hydroxy-4',6'-dimethoxy chalcone
  - 2'-Hydroxy-4',6'-dimethoxy-3'-methyl dihydrochalcone
  - 2'-Hydroxy-4-dimethylaminochalcone
  - 2'-Hydroxy-3',5'-dimethylchalcone
  - 2-Hydroxy-4-n propoxy-5-nitroacetophenone
  - 2'-Hydroxy-4',6',3,4-tetramethoxychalcone

Hypsochromic effect

Indenes

Indole-acetic acid oxidase

Indole-analogue of chalcone

Indoles

Inductive effect

Infra red

## Infra red spectroscopy

Intermolecular complexes Iodine complexes with amine Iodine monochloride Iodine thiocyanate 3-Iodo-6,8-dimethylflavanone Ion exchange chromatography Ionization potential Ionization radiation Iron carbonyl complexes Iron tetracarbonyl Iron tricarbonyl Isobutyl ketone Isocordoin Isocyanatochalcone Isoflavone Isoliquiritigenin (2',4,4'-trihydroxychalcone)

cis-trans isomerism

Isonicotinic acid hydrazide reagent

Iso-octane

Isopentenyl chalcone

\$\mathcal{B}\$-Isopropoxychalcone

Isopropyl alcohol

Isopropyl ketone

Isosalipurposide

Isothiocyanato chalcone

Isoxazole

Isoxazoline derivative

Keto acetal

Keto aldehyde

Kinetics and mechanism of cyclisation of 2'-hydroxychalcone epoxide

Lacquers

- Lactone

5 -Lactones

Lead dioxide

Lead tetraacetate

Leuckart reaction

Limonene

Lipid membrane

Lipoid material

Liquiritigenin

Lithium acetylide

Lithium aluminium hydride-aluminium chloride

Lithium aluminium hydride reduction

Lithium amalgam

Lithium amide

Lucurzid

Luteolin

Magnesium carbonyl

Malonamide

Malonic ester

Manganic acetate

Mass spectrometry

Maximum rate of crystallisation

Mechanism of chalcone formation; base catalysed and acid catalysed

Mecinarone

Meerwein-Pondorf-Verley reduction

Menthone

Mercury cathode

Mesophase

Methacryloyloxychalcone

Methoxyamine

3 -Methoxyaminopropiophenone

4-Methoxyaurone

1-(2-Methoxybenzoyl)-2-phenyl ethylene chlorohydrin

2-Methoxychalcone

cis-3-Methoxychalcone

2-Methoxychalcone epoxide

4-Methoxychalcone

cis-4-Methoxychalcone

4'-Methoxychalcone

Methoxychalcones

p -Methoxychalcone

4-Methoxy-2,4'-dibenzoyloxyohalcone epoxide

4-Methoxy-4'-hydroxy-5'-carboxydihydrochalcone

 $\beta \not \beta$ '-Methoxyimino bis-propiophenone

2'-Methoxy methoxychalcone

2'-Methoxymethoxy chalcone epoxide

2'-Methoxymethoxy-4',6'-dimethoxychalcone

3 -Methoxy-p'-methoxy-p-nitrochalcone

6'-Methoxy-6'-tosylchalcone epoxide

Methylamine

N-Methylaniline

Methylchalcone

m-Methylchalcone

m'-Methylchalcone

p-Methylchalcone

p'-Methylchalcone

∠ -Methylchalcone

 $\beta$  -Methylchalcone

4'-Methyl-d -bromo chalcone

 $\mathcal{L}$  -Methyl- $\mathcal{L}$ -carbethoxy- $\beta$ -phenyl- $\gamma$ -benzoyl-butyric ester

2-Methylcyclohexanone

3-Methylcyclohexanone

∠-Methyl dopa

1-Methylhydrazide

Methyl magnesium bromide

Methyl malonic ester

2-(3-(4-methyl-1-piperazinyl) propoxy-4'-methyl (and 4'-chloro)-chalcone hydrochloride

1-(N-methyl-2-pyrryl)-3-phenyl-1-one

Methyl succinate

3,4-Methylenedioxychalcone

Metyrapon

Michael addition

Michael adduct

Michael condensation

Microhydrogenation, quantitative

Miscellaneous reactions of chalcone dibromides

Molecular compounds

Molecular ion

Molecular orbital calculations

Molecular refraction

Monoperphthalic acid

Morpholine

Naphthalene analogue of chalcone

~ -Naphthyl semicarbazide

Naringenin chalcone

Neohesperidin dihydrochalcone

Nickel

Nitration

4'-Nitrobenzoin

Nitrochalcones

o-Nitrochalcone epoxide

2-Nitrochalcone epoxide

2-Nitrochalcone thiosemicarbazone

3-Nitrochalcone

m'-Nitrochalcone

p-Nitrochalcone

4-Nitrochalcone dibromide

6-Nitrochalcone

p-Nitro-N, N-dimethylaniline

4-Nitro-1,3-diphenyl-but-1-one

Nitroethyl alcohol

Nitrohydroxychalcones

3'-Nitro-4'-hydroxy-2,3-dimethoxychalcone

3'-Nitro-4'-hydroxy-2,5-dimethoxychalcone

Nitro-isopropyl alcohol

4-Nitro-3'-isothiocyanatochalcone

Nitromethane

Nitromethylchalcones

Nitroparaffins

o-Nitrophenols

1-Nitropropane

2-Nitropropane

Nitrosophenyl ketone

Nitrosoyl chloride

o-Nitrotoluene

Nomenclature

Non-fluorescent complexes

Nuclear bromination

Nuclear magnetic response

c¹³-Nuclear magnetic resonance

Nuclear magnetic resonance spectroscopy

Nuclear oxidation

Nuclear substitution

Nucleophilic displacement

Organometallic compounds

Osmium tetraoxide

Oxazine

Oxidation

Oxidation inhibitor

Oxidative cyclisation

Oxidative phenol coupling

Oxidative phosphorylation

Oxidative rearrangement

Oxirane ring

Oxirane ring cleavage by  $\mathrm{BF}_{\mathfrak{F}}$ 

Oxirane ring cleavage by HCl

2-0xo-4,6-diphenyl-3,6-dihydro-1,3-thiazine

V -oxo-d, 13 -diphenyl-d -propylene

2-0xo-4,6-diphenyl-1,2,3,4-tetrahydropyrimidine

Oxonium salt

Oxythallation

Palladium

Palladium (II) acetate

Palladium boride, Pd3B2

Palladium, colloidal

Papain

Paper chromatography

Pentafluorobenzene

2,3,4,5,6-Pentafluoro trans cinnamic acid

2',3,4,4',6'-Pentahydroxy chalcone-4'-glucoside

Pentanethiol

2,3,4,5,6-Pentaphenylbenzophenone

1,1,2,3,3-Pentaphenylpropanol

Perbenzoic acid

Perchloric acid

Perhydro compound

Petroleum waxes

Phellandrene

Phenol

Phenoxy fumarate

Phenoxy maleate

Phenylacetic acid (di-sodium salt)

B -Phenyl acrylophenone

 $\beta$  -Phenyl- $\beta$  (o-amino phenylmercapto) propiophenone

 $\mathcal{A}$  -Phenyl- $\beta$ -benzoyl ethylene

β -Phenyl-Y -benzhydryl butyrophenone

2-Phenyl benzimidazole

B -Phenyl- V -benzoyl- √-benzhydrylbutyrophenone

trans-1-Phenyl-2-benzoylcyclopropane

β -Phenyl- V -benzoylbutyric acid

2- 1-Phenyl-2-benzoylethyl cyclohexan-2,6-dione

∠ -Phenyl-β -benzoyl propionic acid

Phenyl benzyl ketone

B -Phenyl butyrophenone

人 -Phenylchalcone

trans-Phenylchalcone

 $\beta$  -Phenyl chalcone

4-Phenylchalcone

4'-Phenylchalcone

4-Phenyl dihydrocoumarin

Phenylhydrazine

Phenylhydrazone

3-Phenyl-1-indanone

Phenyl lithium

Phenyl magnesium bromide

メーPhenylnitrochalcone

2-Phenyl-2-phenacyl benzyl-2,3-dihydro-1,4-benzopyrone

Phenyl potassium

Phenyl sodium

1-(Phenyl sulfinyl)-2,4-diphenyl-3-buten-2-ol

 $\angle$ -(Phenylsulphonyl) chalcone

Phenyl sulphonyl hydrazide

Phenyl styryl ketone

Phenyl sulfenyl chloride

Phenyl sulfenyl methyl ester

o-Phenylene diamine

Phlorizin

Phosphoric acid

Phosphorylated esters of chalcones

Photochemical demethylation

Photochemical dimerization

Photochemical isomerization

Photochemical oxidation

Photochemistry, solid state

Photoconducting composition

Photocross linkable copolymers

cis-trans Photo-isomerization, Mechanism and kinetics

Photolysis

Photo-oxidative cleavage

Photosensitive polymeric material

Photo-thermographic emulsion

Picric acid

Pinacol

Piperidine

Piperizine

pKa

Plastics

Platinum

Platinum black

Platinum oxide

Polarization

Polarographic reduction

Polarographic reduction potential

Polyacrylates

Polyamide column chromatography

Polychrome isomers

Poly (dimethyl siloxane)

Polyester film

Poly fluorochalcones

Polyhydroxylated chalcons

Polymerization catalyst

Polymethyl methacrylate

Polymorphic forms of chalcone

Polymorphism

Polyolefinic polymers

Polyphenols

Polyproplene polymer

Potassium amide

Potassium borohydride

Potassium tert. butoxide-t-butyl alcohol

Potassium cyanide

Potassium ferricyanide

Potassium iodide

Potassium isocyanide

Potassium persulphate

Prenyloxychalcone

Preparative T.L.C.

Promoters

 $\beta$  -Propoxychalcone Protolytic equilibrium Proton magnetic resonance PVC resin sheets Pyranochalcone Pyran derivative Pyrazolines Pyridine Pyridine analogue of chalcone Pyridine-borane reagent Pyrolysis Pyrolytic oxidative cleavage Pyrrlyl analogue of chalcone Pyrrole 3-Pyrrole-3-aldehydechalcone Pyrrolidine 1 (2-pyrryl)-3-aryl-prop-3-one Pyrylium salt

Quantum chemical methods
Quinacetophenone
Quinacetophenone monomethyl ether
Quinoline
Quinoline analogue of chalcone

Radical anion

Raman spectrum

Raney nickel

Rearrangement ions

Reduced benzofuran chalcone derivative

Reduction dimers

Reductive amination

Reductive cyclisation

Reductive dehalogenation

Relative basicities of chalcones

Resacetophenone

Resacetophenone dimethyl ether

Resin

Resinification

Resorcyclic chalcone

 $R_{\mathbf{f}}$  values of benzenoid chalcones

Ferrocene analogue of chalcones

Furyl analogue of chalcone

Pyrryl analogue of chalcone

Thienyl analogue of chalcone

Ring cyclisation

Ritter reaction

Rotation about Cx - CB bond

Rotational isomers

Ruthenium (II) complex

Saccharin

Salicylic acid

Salicylic acid chalcone

Schmidt reaction

Scintillators

Secondary amine-iodine complex

Selenium dioxide

Selenophene analogues of chalcone and its analogue

Semicarbazone of chalcone and its analogue

Sigma (O) constant

Silicone dielectric fluid

Silver halide emulsion

o-silylated ketenes

Skeletal rearrangement

Sodium

Sodium-alcohol

Sodium amide

Sodium azide

Sodium bisulphite

Sodium borohydride

Sodium borohydride-boron trifluoride

Sodium dithionate

Sodium enol methyl malonic ester

Sodium hydrogen sulphide

Sodium hydrogen sulphite

Sodium-potassium dependent ATP-ase

Sophoradin

Spectrophotometric analysis

Stannous chloride

Stereochemistry

Stereoisomeric pairs

Stereoisomerism

Stereoisomers

Steric effects

Steric hindrance

Styrene-maleic anhydride

N-substituted-4'-aminoalkyl-2',4-dihydroxy chalcone salt

p-substituted benzohydride

4-substituted chalcone

4'-substituted chalcone

Substituted chalcones

d -substituted chalcone

Substituted chalcone epoxide

Substituted urea

Sulfenyl compounds

Sulpholane

Sulphonation

Sulphonic acid derivative of chalcone

Sulphur

Sulphuric acid-acetic anhydride

Sulphuric acid ester of chalcone

Sulphuric acid-methanol

Sulphuric acid-nitric acid

Sweeteners

Syn conformation

Syn-s-cis-conformation

Tautomerism

Terpene

Tetrabromo-o-benzoquinone

Tetrahydrofuran

3,3',4,4'-Tetrahydroxy chalcone

2',4,4',6'-Tetrahydroxy chalcone

2',4,4',6'-Tetrahydroxy chalcone-2,  $\beta$ '-glucoside

3,2',4',6'-Tetrahydroxy-4-propoxy dihydro-4, p'-neo hesperodside

2',3,4,4'-Tetramethoxy chalcone epoxide

5,7,3',4'-Tetramethoxyflavanonol

Tetramethoxy eriodictyol chalcone

+ 3',4',5,7-Tetra-o-methyl taxifolin

Tetraphenyl borocopper

1,2,4,5-Tetraphenylcyclohexan-1,2-diol

Tetraphenylcyclopentadienone

1,3,4,6-Tetraphenyl-3,4-dihydroxy-1,5-hexadiene

1,3,4,6-Tetraphenyl-hexan-1,6-dione

1,3,6,8-Tetraphenyl-1,8-octadione

1,1,3,3-Tetraphenyl-1-1-propanol

2,3,3,3-Tetraphenyl propyl phenyl ketone

Tetraphenyl tin

Thallic acetate

Thallic nitrate

1,3-thiazium salts

Thienyl analogue of chalcone

Thin-layer chromatography

Thioalcohols

4'-Thioalkyl chalcone

Thioaurones

Thiobarbituric acid

Thiocyanogen

Thiomicid

Thiphene analogue of chalcone

Thiophene-pyridine

Thiophenols

Thiosemicarbazone of chalcone and its analogue

Thiourea

Titanium tetrachloride

Toluene thiol

p-Tolylamine

B-Tolychalcone

1-(-ptolyl)-2-hydroxy-3-chloro-3-phenyl-propan-1-one

2'-Tosychalcone epoxide

2'-Tosyl-6'-methoxy chalcone

Tosyl-hydrazine

Tosyl hydrazone

 $n-\eta$  * and  $\eta$  -  $\eta$  * transitions

Transmutation

Transmission effects

Transoid conformation

Triamino guanidine salt

Tributyl tin

Trichloroacetic acid

Trifluoroperoxyacetic acid

3,4,4'-Trihydroxy-3'-carboxychalcone

2,2',4-Trihydroxychalcone

2,4,4'-Trihydroxychaloone

2',4',6'-Trihydroxychalcone

3,2',4'-Trihydroxy-4-methoxy-dihydrochalcone

Trimethoxy aluminium hydride

2',4,4'-Trimethoxychalcone (vesidryl)

4,2',4'-Trimethoxychalcone epoxide

(±) 4',5,7-tri-o-methyl aromaden-drin

Triphenyl aluminium

1,5,5-Triphenyl-4-benzoyl-hex-1,3-diene

1,3,5-Triphenyl-4-benzyl-1-pentene

triphenyl cadmium lithium

 $\beta$ ,  $\gamma$ ,  $\gamma$  -Triphenyl- $\gamma$ -hydroxybutyrophenone

Triphenyl indium

Triphenyl methyl sodium

1,3,5-Triphenyl-pentan-1,5-dione

trans 1,1,3-Triphenyl-2-propen-1-ol

1,3,5-Triphenyl pyrazolines

2,4,6-Triphenylpyridine

2,4,6-Triphenyl pyrimidine

2,4,6-Triphenyl pyrylium chloride

Triphenyl thallium

Triphenyl tin lithium

Triplet mechanism

2,4,6-Trisubstituted pyridine

Triton-B

Ultraviolet absorption-filter

Ultraviolet irradiation

Ultraviolet spectra, cis-trans isomer of chalcone

∠, β -Unsaturated alcohol

 $\mathcal{A}$ ,  $\beta$  -Unsaturated ketone

Unsaturated ketoximes

Unsaturated trimer

Uranyl chloride

Urea

Uvaretin

Vanadous salt

Veratraldehyde

Vesidryl (see 2',4,4'-trimethoxychalcone)

Willgerodt-Kindler reaction

Wilson's boric acid test

Xanthine oxidase

Xanthoangelol

X-ray crystallography

Zinc acetate

Zinc-ethanol-acetic acid

Zinc-mercury-acetic acid